Cost benefit analysis of Building for Climate Change amendments to the Building Act 2004

Report for the Ministry of Business, Innovation and Employment

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Glossary

Abbreviation	Stands for
BAU	Business as usual
BCAs	Building Consent Authorities
BCR	Benefit-cost ratio
BEES	Building Energy End-use Study
BRANZ	Building Research Association of New Zealand
C&D	Construction and demolition
CBA	Cost benefit analysis
DVR	District Valuation Roll
EECA	Energy Efficiency and Conservation Authority
ERP	Emissions Reduction Plan
EUI	Energy Use Intensity
EPRs	Energy performance ratings
GDP	Gross Domestic Product
GHG	Greenhouse gas
HUD	Ministry of Housing and Urban Development
KtCO2e	Kilotonnes of CO_2 equivalent
MBIE	Ministry of Business, Innovation and Employment
MtCO2e	Megatonnes of CO_2 equivalent
NABERSNZ	NABERSNZ is an adaptation of the National Australian Built Environment Rating System (NABERS)
NPV	Net present value
NZGBC	New Zealand Green Building Council
WMP	Waste minimisation plan

Executive summary

The Ministry of Business, Innovation and Employment (MBIE) is proposing changes to the Building Act 2004 (the Act) to support actions towards the Government's Emissions Reduction Plan (ERP). As part of the Building for Climate Change work programme, MBIE has considered a range of policy options to meet three key objectives for amendments to the Act.

MBIE proposes a combination of changes (Options 1c, 2c, and 3b) to address all three objectives, as summarised in the table below.

Objectives		MBIE's preferred option
1	Enable consumers, those that lease or rent building space, and the Government to have better information on the energy performance of existing buildings in such a way that improves energy efficiency across the building stock.	**Option 1c: Energy performance ratings** – amend the Act to require certain buildings to hold an energy performance rating.
2	Enable more consistent requirements for people to consider, recognise or reduce the social cost of construction and demolition waste (information, regulatory and externality issues).	**Option 2c: Waste minimisation plans** – amend the Act to add waste minimisation plan requirements.
3	Align the focus for both the building sector and regulators to support building emissions reduction and climate resilience.	**Option 3b: Clarify role of climate change in Act** – Amend the Act's purposes and principles and enable the collection of information to align the sector and regulators' focus on building emissions reduction and climate resilience.
All	To address all three objectives.	**Combined package (Options 1c, 2c, 3b).**

MBIE has asked us to assess the above options for legislative changes to the Act. This report provides a cost benefit analysis (CBA) for MBIE's recommended changes. There are separate CBAs for the introduction of waste minimisation plan requirements (WMP) and energy performance rating (EPR) requirements. We assess the combined package of changes in the final section of our report. Alongside our quantitative CBA, we highlight important potential non-quantified impacts and sensitivities that should be considered together with the quantitative figures.

Context within which the CBA results should be considered

Our CBA results should be considered within the context that:

- further details on the exact application of the proposed changes are expected to be refined through policy development and the design of associated regulations
- there are significant gaps in the data currently available, which demonstrates the issues some of the proposed changes are intended to address. As such, we have had to make best use of available data in the time available. We highlight where there are challenges and have undertaken sensitivity analysis of key inputs that make a material difference to

the results. This shows the issues the proposed information provision requirements aim to address and illustrates the unquantified benefits from informing policy design and decision-making with better knowledge and confidence of impacts.

- the direct costs from the proposals are small relative to indirect impacts, there is greater uncertainty in the indirect impacts, and the quantitative results need to be considered alongside the sensitivities and the non-quantified impacts. Further, the policies provide a nudge to consider waste minimisation and energy efficiency but actions that lead to the indirect impacts are voluntary, as the proposals are currently stated. We therefore expect parties will only make investments where they feel the payoff warrants it and the infrastructure and markets exist to support certain decisions. For instance, if recycling/reuse is not an option in some areas, waste reduction may be all that is achievable in those areas. This suggests that sensitivities where indirect benefits to parties exceed the associated indirect costs should be more likely in practice.

Our findings

The net result for energy performance ratings is sensitive to assumptions, with significant non-quantified benefits

The proposed EPR requirements for owners of new and existing commercial, public, industrial, and large-scale residential buildings generate a quantified net present value (NPV) of between -$606 million and $487 million (with a central estimate of -$29 million) between 2023 and 2050 and a benefit cost ratio (BCR) of 0.47 – 2.55 (with a central estimate of 0.96). This suggests relatively neutral and uncertain implications in terms of quantitative costs and benefits.

These results are dependent on several uncertain parameters. Like early analyses undertaken with respect to office buildings, we assumed that EPR requirements would indirectly incentivise building owners to invest in energy efficiency upgrades (resulting in energy cost savings). There are gaps in the available evidence base and a range of investments that vary from simple behaviour changes to large capital investments. Given this, we estimated upgrade costs based on a conservative repayment period of three years (consistent with early analyses) but consider one- and five-year options and different rates of possible no-cost upgrades in our sensitivity analysis. As our BCR is close to 1, improvements in either benefits or costs would result in the benefits breaking even.

In addition, the results are very sensitive to the assumed Energy Use Intensity (EUI) savings as a result of the policy. Our sensitivity tests revealed that, separate to efficiency upgrade costs, it would not take a significant increase to EUI reduction rates to produce a positive quantified NPV/net benefits. Further, past studies using the more specific data available in relation to New Zealand office buildings have also identified net benefits in applying the policy to larger office buildings, suggesting that the building types covered by the policy may warrant further analysis when designing regulations.

Importantly, the quantitative NPV also needs to be considered alongside the significant potential non-quantified benefits from improved productivity and health due to heathier and more energy-efficient buildings. For example, an Australian review suggests that including productivity benefits could increase net benefits of mandatory ratings for commercial buildings by between AU $110.5 million to

AU $167.8 million, two to three times the net benefits of the programme, though noted the estimates were too uncertain to include in its quantitative estimate as well.[1]

The waste minimisation plans are marginally beneficial, and very sensitive to material recovery costs, but potentially significant if able to reduce overall waste volumes

The quantified NPV of WMPs is $66 million between 2023 and 2050, with a BCR of 1.01. However, the result is highly sensitive to the indirect costs arising from the recovery of materials, which, depending on assumption sources, could result in a range from -$1.5 billion to $1.8 billion given the volumes this applies to. We have taken the mid-point where there are different potential sources for inputs of material recovery costs and note the most recent estimate looks beyond Auckland and has lower overall costs than the Auckland-based study. Further, we expect material recovery costs would decrease as a result of additional demand from this policy.

The quantified NPV may also be larger if waste volumes reduce over the period to 2050 as a result of this policy (with sensitivities ranging from a quantified NPV of $108 million to $657 million if the time horizon to 2050 is taken),[2] as may be expected based on certain findings in the literature.

Further, the quantitative NPV needs to be considered alongside the potential non-quantified benefits associated with this policy.

Proposed changes to the purposes and principles of the Act are expected to provide incremental (non-quantified) impacts

The proposed changes to the purposes and principles of the Act would provide incremental impacts to the introduction of WMPs and EPRs, which we have not quantified, including:

- improved compliance
- early and/or increased adoption (impacting costs and benefits)
- potentially increased enforcement (impacting costs and benefits).

In addition to these impacts, the changes to the purposes and principles are likely to result in greater:

- direct cost to implement the legislation
- ease of adjusting settings as required to support climate objectives (reducing the relative cost)
- certainty for the public in relation to meeting emissions budgets.

The quantitative impact of the package of all proposed changes is also marginal, with significant non-quantified benefits that need to be considered

Table 1 shows the overall quantified results for the combined package of changes. Noting the sensitivities above, this shows marginal net quantitative benefits of $37 million that need to be considered relative to the sensitivities and potentially significant non-quantified benefits. Incorporated

[1] *Commercial Building Disclosure Program Review*, ACIL Allen 2015, p57. Cited in Energy Action and EnergyConsult (2018).

[2] The result is as low as -$12 million if a shorter time horizon is used.

in this figure are the benefits associated with reducing emissions by 12.6 megatonnes of CO_2 equivalent (MtCO2e).[3]

In addition, there are potential dynamic impacts in terms of driving markets for material recovery and reuse/recycling and the breadth/uptake of energy efficiency upgrades. These dynamic impacts have benefits that are not easily quantified. We note that the direct costs from the proposals are a very small portion of the impacts of the proposals and are significantly outweighed by the indirect impacts to developers and building owners.

Table 1: Quantified CBA results

	NPV	BCR	Included emissions reduction
Waste minimisation plans	$66m	1.01	11.7 MtCO2e
Energy performance ratings	-$29m	0.96	0.9 MtCO2e
Total package	**$37m**	**1.00**	**12.6 MtCO2e**

[3] https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references or https://databank.worldbank.org/metadataglossary/millennium-development-goals/series/EN.ATM.CO2E.KT

1. Introduction

The building and construction sector is an important contributor to New Zealand's community, businesses, and economy. The sector is New Zealand's fourth-largest employer, accounting for 10 per cent of New Zealand's workforce, and is the nation's fourth-largest industry by GDP[4] (valued at $22.46 billion in 2021).[5] It is also estimated that in 2018 the building and construction sector was responsible for 15 per cent of all New Zealand's domestic emissions, and construction and demolition (C&D) waste accounted for 40-50 per cent of all material going to landfill.[6] The Ministry of Business, Innovation and Employment (MBIE) is proposing changes to the Building Act 2004 (the Act) to reduce the building and construction sector's emissions and support the construction of more climate-resilient buildings.

MBIE has asked Sapere Research Group (Sapere) to undertake a cost-benefit analysis (CBA) of the proposed legislative changes. In this report, we set out detail on our approach and the results of our analysis. Further details relating to the design and implementation of the proposals are planned to occur through subsequent development of the regulations. As such, to estimate impacts, we have made assumptions about what and who the regulations may apply to, and how behaviour may change.

1.1 What is being proposed and why

New Zealand's first Emissions Reduction Plan (ERP), published in May 2022, sets out actions to support the goals contained in the Climate Change Response (Zero Carbon) Amendment Act 2019 (the Zero Carbon Act). These include actions for the building and construction sector to reach near zero emissions by 2050. In response, MBIE has set up the Building for Climate Change programme.

As part of the Building for Climate Change work programme, MBIE has considered a range of policy options to meet three key objectives for amendments to the Act. MBIE proposes a combination of options are implemented (options 1c, 2c, and 3b) to meet these objectives, as summarised in Table 2 below. Consultation undertaken on the ERP and targeted stakeholder engagement indicate support for the changes proposed.

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[4] MBIE, *Discussion Document: Building System Reform* (April 2021)

[5] The value of the construction sector measured by the value of building consents for all buildings in New Zealand in FY20 according to Stats NZ.

[6] Level, (2022). Minimising waste, https://www.level.org.nz/material-use/minimising-waste/

Table 2: Objectives for amendments to the Building Act 2004 and MBIE's preferred policy options to address each objective

Objectives		MBIE's preferred option
1	Enable consumers, those that lease or rent building space, and the Government to have better information on the energy performance of existing buildings in such a way that builds energy efficiency across the building stock.	**Option 1c: Energy performance ratings** – amend the Act to require certain buildings to hold an energy performance rating.
2	Enable more consistent requirements for people to consider, recognise or reduce the social cost of construction and demolition waste (information, regulatory and externality issues).	**Option 2c: Waste minimisation plans** – amend the Act to add waste minimisation plan requirements (*without* mandating minimum waste minimisation requirements). This aims to enable better waste management.
3	Align the focus for both the building sector and regulators to support building emissions reduction and climate resilience.	**Option 3b: Clarify role of climate change in Act** – Amend the Act's purposes and principles and enable the collection of information to align the sector and regulators' focus on building emissions reduction and climate resilience.

The changes are intended to support actions in the ERP and address three core policy problems (discussed in greater detail in the regulatory impact statement):

- **The building regulatory system does not enable consumers and Government to easily understand the energy efficiency of buildings.** The information available on building energy efficiency is inconsistent and not comparable. Consumers, those who lease or rent building space, and the Government have limited information on the energy performance of existing buildings, and there are externalities (impacts to parties beyond those making the decisions giving rise to the impact) and potential market failures in relation to building energy performance.
- **The building regulatory system does not incentivise action on construction and demolition waste minimisation.** There are inconsistent requirements for people to consider, recognise or reduce the social cost of construction and demolition waste (with information, regulatory and externality issues).
- **There is a lack of clarity and focus on climate change for building and construction sector stakeholders and regulators.** The purposes and principles of the Act do not clearly or sufficiently reflect New Zealand's climate change goals as set out in the Zero Carbon Act.

There is also limited information available on building emissions and climate resilience. This issue cuts across all the core policy problems.

1.2 We have used a cost benefit analysis framework to assess the proposals

The CBA framework looks at the incremental costs and benefits that arise relative to the counterfactual – usually the status quo (the Base Case).[7] Once the incremental costs and benefits are identified for each option within the specified timeframe, the CBA then sums all the discounted cash flows (costs and benefits) for each option to calculate the net present value (NPV). The NPV is calculated by subtracting the total present value of benefits from the total present value of costs. Generally, if the NPV of an option is positive, this means that the option generates net benefits to the New Zealand community and is preferred relative to the Base Case. One limitation of a CBA is that it sometimes is only used to consider quantitative costs and benefits. Our report highlights the importance of non-quantified costs and benefits, which we have noted in this report but are not included in the summary CBA/BCR (benefit-cost ratio) tables.

We also calculated a BCR. The BCR is estimated by dividing the total present value of the quantified benefits for each option by the total present value of the quantified costs for each option. If most impacts can be quantified, or the unquantified costs and benefits make little difference overall, then a positive BCR (>1) indicates that the option generates a net benefit to the community, while a negative BCR (<1) indicates the option generates a net cost to the community, relative to the Base Case. Note that a BCR, like an NPV, only captures quantified costs and benefits, so unquantified impacts need to be considered alongside the BCR. The BCR can also be interpreted as a measure of return. For example, if an option had a BCR of 1.5, this could be interpreted as the option generating $1.5 in benefits for every $1 invested into the option.

1.3 Quantitative analysis focuses on energy performance ratings and waste minimisation plans

We have undertaken a separate CBA for EPRs (Option 1c) and WMPs (Option 2c). As part of these assessments, we have included the cost of collecting information that is expected to be required for these specific initiatives. We separately discuss the qualitative impacts of information requirements if they are applied beyond WMPs and EPRs as part of proposed changes to the purposes and principles of the Act (Option 3b), and the additional costs and benefits that these may generate. We then report on the combined CBA for these changes as a package, as proposed by MBIE.

1.4 Report outline

This remainder of this report is set out as follows:

- Section 2 outlines the methodology and impact assessment for **EPRs (Option 1c)**.
- Section 3 outlines the methodology and impact assessment for **WMPs (Option 2c)**.

[7] A counterfactual is a common point of comparison that allows the identification of incremental costs and incremental benefits. In this analysis the Base Case is the counterfactual because the proposed regulations an expansion of the Base Case.

- Section 4 discusses the costs and benefits that may apply to **information requirements** and changes to the **purposes and principles (Option 3b)**.
- Section 5 presents the results for the whole package (Options 1c, 2c and 3b).
- Appendix A provides detail on our modelling and assumptions.

2. Cost benefit analysis of energy performance ratings

> The proposed energy performance rating requirements generate a quantified NPV of between -$606 million and $487 million (with a central estimate of -$29 million) between 2023 and 2050 and a BCR of 0.47 – 2.55 (with a central estimate of 0.96). This suggests relatively neutral and uncertain implications in terms of quantitative costs and benefits. Included within the central estimate is the quantified benefit associated with decreasing emissions by 857 kilotonnes of CO_2 equivalent (ktCO2e) over the period.
>
> The result is highly sensitive to the assumptions made the about the efficiency upgrade costs that indirectly arise from this option and which make up 95 percent of total costs.
>
> However, the quantitative NPV needs to be considered alongside past estimates with higher results for large office buildings only as well as the significant potential non-quantified benefits. For instance, a review of the Australian commercial building disclosure programme estimated that total productivity benefits could increase the net benefits of the programme by 2 to 3 times,[8] which if applicable would result in net benefits for this option.

This section outlines the CBA approach and framework for the proposed regulations on energy performance ratings and summarises the results.

2.1 Options for analysis

This cost benefit analysis compares the **Base Case** with the policy intervention:

- **Base Case:** we assume no further changes to the Building Act or other policies or regulations relating to energy efficiency of buildings (while changes may be possible, they would need to be separately assessed and we would not wish to predict these).
- **Option 1c:** energy performance ratings are required for owners of new and existing commercial, public, industrial and large-scale residential buildings (with associated penalties and infringement fees for non-compliance).

The analysis below focuses on comparing the implementation of EPR requirements (Option 1c) with the Base Case.

For **Option 1c**, while we note the legislation is enabling, for the purposes of estimation we assume:

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[8] *Commercial Building Disclosure Program Review*, ACIL Allen 2015, p57. This report found that total productivity benefits for the Australian programme were in the range of AU$110.5 million to AU$167.8 million but were excluded due to the lack of robust evidence.

- EPR requirements are implemented from 2024, with implementation costs spread over 2024 and 2025 and impacts linearly increasing over five years from 2025.
- EPRs are required for existing commercial, public, industrial and large multi-level apartments over 2,000 square metres. We have excluded government-leased offices from any incremental impacts when assessing the policy intervention as government agencies with large owned or leased office accommodation are already required to undertake an energy efficiency assessment as part of the Carbon Neutral Government Programme.[9]
- We have modelled costs out to 2030 (when the policy is expected to be fully implemented), as well as the resulting benefits associated with those costs to 2050.We have not considered or modelled any costs and benefits of re-ratings, which could be considered further when designing the scheme.
- Penalties and infringement fees apply if building owners intentionally do not hold, prominently display, or provide an EPR to those required under regulations, or knowingly making a false or misleading statement about an EPR.
- A passive enforcement approach from MBIE and local authorities.

We expect future regulations will provide detail on the design and application of EPRs such as whether they apply as a base or whole building rating.[10] We have provided analysis on whole buildings given data is not available on base consumption for most building types considered. As a result, we have assumed a lower portion of energy savings than earlier analysis undertaken in relation to commercial office spaces by Energy Action and EnergyConsult (2018).

2.2 Our cost benefit analysis framework

It is important to note that our CBA model only accounts for costs incurred up to 2030 and the benefits arising from these costs. This is because buildings will likely have access to a different set of technologies and tools to reduce energy usage rates beyond 2030, but we do not have any estimates of the potential efficacy of such upgrades. Rather than speculating on the potential efficiencies that these future upgrades could achieve, we have instead chosen to undertake a conservative estimate based on costs and subsequent benefits that can be attributed to changes (such as upgrades and rating costs) that occur between 2023 and 2030. Detail on our modelling assumptions can be found at 5.Appendix A.

2.2.1 Quantified cost categories

Table 3 summarises the quantitative costs of EPR requirements (Option 1c), relative to the Base Case.

[9] This has applied to government agencies since January 2021. It applies to government agencies that are subject to the Government Property Functional Leadership Mandate which own or lease office accommodation with an occupied area that is 2000m2 or more.

[10] A base build rating measures the energy performance of a building's core services such as lifts, lobby and stairwell lighting, common toilets, and air conditioning. A whole building rating measures the base build rating as well as the floor and areas occupied by tenants, such as computers, lighting, data centres and staff kitchens. (https://www.nabersnz.govt.nz/about-nabersnz/types-of-ratings/, accessed 8 August 2022.)

Table 3: Quantified costs for EPRs

Cost	Description	Relevant party
Direct costs		
Rating costs	Cost of obtaining a rating from a qualified assessor in the market. We assume that the rating fees would be lower in the case that ratings are mandatory, as assessors join the market and competition increases, pushing down the rating cost.	Building owners
Implementation and ongoing costs	The government will incur costs in developing and monitoring the regulations. This is likely to also include guidance, monitoring receipt of information disclosed under disclosure requirements, and potential enforcement of the regulations.	Government (MBIE)
Indirect costs		
Metering costs	To get a rating for a building, upgraded or additional metering equipment is likely to be required for some buildings, to allow for accurate energy consumption measurement. For instance, office buildings may not be wired separately to allow for base building systems and tenant distribution boards to be billed for their respective energy consumption.	Building owners
Energy efficiency upgrade costs	Better information provision about the energy efficiency of buildings is likely to incentivise building owners to invest in improved energy efficiency measures.	Building owners

2.2.1.1 Costs to building owners

Costs to building owners include the:

- direct cost of obtaining a rating, which would be incurred at recurring intervals as specified in the regulations (includes an estimated fee/cost for someone to undertake the rating)
- indirect costs of:
    - one-off cost of upgrading metering equipment (where necessary) to allow for accurate data as part of the rating assessment and data gathering required for the assessment
    - cost of energy efficiency upgrades, which building owners are likely to be incentivised to invest in when EPRs are compulsory to disclose (we discuss our approach and sensitivities around these costs further in section 2.4.1).

2.2.1.2 Costs to government

The direct costs to government include implementation of the regulations and ongoing costs. Implementation costs would include developing the regulations and providing guidance to industry. Once implemented, there would be ongoing costs of MBIE's information management and compliance functions, which include education and enablement, monitoring, and compliance and enforcement activities.

2.2.2 Quantified benefit categories

Table 4 summarises the quantitative benefits of Option 1c, relative to the Base Case.

Table 4: Quantified benefits of EPRs

Benefit	Description	Relevant party
Indirect benefits		
Reduced energy bills	As an indirect effect of mandatory EPRs, building owners will be incentivised to invest in energy efficiency improvements to improve their building rating. As a result, upgraded buildings will experience a greater rate of energy use reduction. Tenants will receive the main benefit of this through reduced energy bills. There will also be reduced energy bills for the building owner where central services like heating and cooling systems, lifts and lighting are commissioned more effectively or changed to more energy-efficient technologies and/or building owners may be able to benefit from increased rents if they invest in improving building energy efficiency.	Tenant, building owners
Reduced carbon emissions	Increased energy efficiency of buildings could also result in reduced emissions. This would benefit all New Zealanders.	Society

2.3 Quantified cost benefit analysis results for energy performance requirements

The results in Table 5 show the present value of total costs and benefits, relative to the Base Case. As previously mentioned, this only includes capital and ratings costs for business incurred up until 2030 and benefits through to 2050 that accrue from those costs.

Appendix A outlines the detailed data and assumptions underpinning the analysis. Note that these are rounded figures.

Table 5: CBA results in net present value ($million) for commercial, public (excluding offices), large-scale residential, and industrial buildings

	NPV ($million)
Costs	
Direct costs	
New ratings for buildings	$37
Costs to government	
Implementation costs	$0.5
Ongoing costs (compliance, monitoring, enforcement, etc)	$3.0
Indirect costs	
Metering upgrades	$0.8

Energy efficiency upgrades	$789
Total costs	**$830**
Benefits	
Indirect benefits	
Power bill savings – value ($)	$688
GHG emission reductions – value ($)	$113
Total benefits	**$801**
NPV	**-$29**
BCR	**0.96**

2.3.1 Distribution of impacts

Figure 1 shows that the quantified costs are dominated by the costs to building owners which make up 99 per cent of costs. This includes the direct costs of ratings ($37 million) as well as the major indirect cost of efficiency upgrade costs ($789 million). In contrast, the direct one-off costs to MBIE to implement the regulations and the direct ongoing costs to both MBIE (associated with oversight and information management) and to territorial authorities (for compliance monitoring and enforcement) together only represent less than 1 per cent of costs.

Figure 1: Distribution of quantified EPR costs

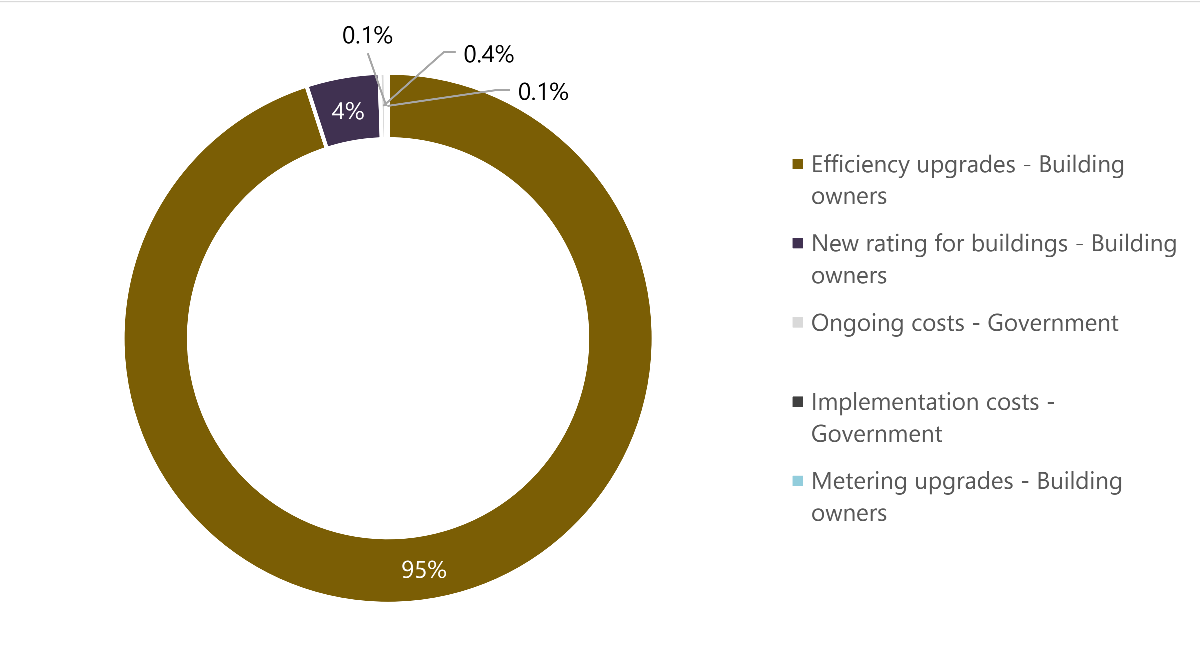
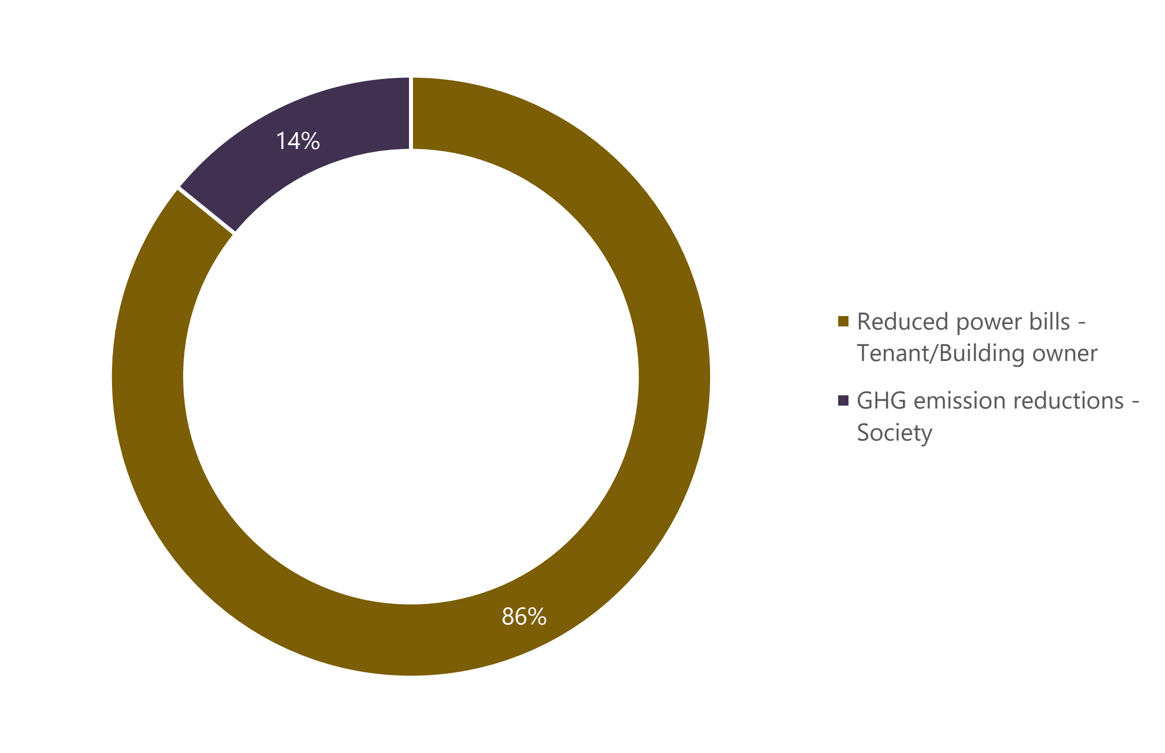


Figure 2 provides an overview of the quantified benefits of EPRs. Most benefits are indirect and come from reduced energy costs accruing to tenants or building owners ($688 million or 86 per cent of quantified benefits). The GHG emissions reductions account for $113 million in present value terms, resulting from a modelled reduction of 857 ktCO2e over 2023-2050.

Figure 2: Distribution of quantified EPR benefits



2.3.2 Unquantified impacts

In addition to the quantified economic benefits, several non-monetised benefits exist. These are discussed below but are not quantified in the CBA, due to difficulty in estimating these types of impacts with the time and information available.

2.3.2.1 Health, wellbeing, and productivity benefits

The built environment can impact our health, wellbeing and productivity through various factors including light, noise (indoor and outdoor), temperature, humidity, ventilation and air movement, indoor air quality and chemical contaminants from indoor and outdoor sources.

Research shows that these built environment factors above can lead to or exacerbate a range of health conditions, such as respiratory illness (e.g. asthma), and other preventable outcomes.[11,12] These factors in workplace environments can lead to reduced productivity, increased absenteeism, and increased staff turnover.

[11] HEAL (2020), *HEAL Briefing: Healthy buildings, healthier people*. HEAL.

[12] Ministry of Health (2022). Healthy Homes Initiative, https://www.health.govt.nz/our-work/preventative-health-wellness/healthy-homes-initiative

There is a wide body of research and evidence of the links between buildings and health[13] and the health impacts of living in energy-inefficient buildings, which have been studied extensively in New Zealand and the United Kingdom.[14] Ultimately, there is a cost to society from the health outcomes of unhealthy buildings, particularly to the health sector. As such, improving the building stock in both residential and workplaces is of interest to health.

However, the relationships between buildings and health are complex. While the relationships are well established in the literature, accurate estimation is difficult. The difficulty in estimation has meant we did not attempt to estimate the health and wellbeing benefits of the proposed changes.

2.3.2.2 Asset values

Studies have found that highly rating buildings (equivalent to high NABERSNZ) can increase the asset value for the building owner. One study found an 8 per cent increase in asset value over traditional buildings.[15] This finding reflects the demand for energy efficiency. Building owners can desire energy-efficient buildings and are therefore willing to pay a premium for it.

Similar to the argument for increases in rent, asset values increases are a function of rent increases, i.e. the asset value is equal to the sum of all future cash flows, all else being equal. Where rent increases are equal to the resulting reduction in energy bills, this has already been captured in the quantified CBA. However, if investments enable the building owners to attract new and more profitable tenants as a result of their investments, or asset value increases are greater than the net present value increases that occurs as a result of rent increases, this would be an additional benefit to that captured in our quantified benefits as would cashflows beyond the period modelled.

2.3.2.3 Energy infrastructure demand decreases

Reduced demand for energy from this policy, which is captured in the model as part of reduced power bills, would (all else equal) reduce or delay the need for the construction of new electricity infrastructure (generation and any resulting transmission and/or distribution infrastructure) in New Zealand. This would result in avoiding or deferring the associated monetary and embodied carbon costs. Electricity demand reductions that result from this policy would also relieve any pressure on electricity that may arise from the electrification of fossil-fuel reliant sectors such as transport.

2.4 Our analysis highlights the sensitivity of the final results

Our sensitivity analysis shows that the results are sensitive to changes in key assumptions. As our BCR is close to 1, improvements in either benefits or costs would lead us to break-even. As the results are

[13] Chisholm et al. (2019). What can we learn from Healthy Housing Initiatives? New Evidence from the Wellington Well Homes scheme, https://blogs.otago.ac.nz/pubhealthexpert/what-can-we-learn-from-healthy-housing-initiatives-new-evidence-from-the-wellington-well-homes-scheme/
[14] HEAL (2020).
[15] NABERS (2022), https://www.nabersnz.govt.nz/why-nabersnz/owners/

driven in large part by the assumed energy savings and energy efficiency costs, these are the sensitivities we have focused on.

2.4.1 Sensitivities on energy efficiency upgrade costs

In our analysis, we assumed that the proposed EPR requirements would indirectly incentivise building owners to voluntarily invest in energy efficiency upgrades, resulting in energy cost savings. We considered a range of options for how to factor in the costs of these energy efficiency upgrades, given different possible behaviours and scenarios that may result from the policy change.

Building owners are likely to only invest in upgrades where their private benefit outweighs the cost, but these will vary in the level of investment and benefit payback period. There may be many low or minimal cost changes that can result in large energy savings (such as programming heaters to turn off overnight, or ensuring even temperatures are maintained). More complex buildings may have more opportunity for energy efficiency improvement through building commissioning changes. There are also more capital-intensive investments that produce large benefits but at a significant cost (such as air conditioning or boiler upgrades). For instance, aggregate information from a major property group's portfolio in Australia from over 500 individual energy efficiency projects showed average costs ranging from $32,000 to $3.2 million, and average payback periods that ranged from 3.3 years to 167.3 years (CIE, 2019). In other cases, owners of older buildings may determine that it does not make financial sense to invest in efficiency upgrades, despite a low rating (such as Victorian buildings in regional areas like Oamaru, Timaru, Dunedin and Invercargill).

There were gaps in the data and information available about the costs of energy efficiency investments, their impact on energy savings, and importantly how these apply to different building types. For consistency, we followed the approach taken in a 2018 CBA analysis by Energy Action and EnergyConsult for mandatory ratings for office buildings.[16] The authors estimated an average cost of investment in efficiency upgrades by assuming that building owners implemented an investment equivalent to the energy savings over an average three-year simple payback period, following earlier work informed by discussions with EECA. In addition, we assume that 10 per cent of the existing building stock will achieve energy savings with no-cost upgrades.[17]

We considered this appropriate in lieu of more recent and relevant research, given the nature of the policy is likely to incentivise many building owners to first implement low-cost changes that deliver the highest pay-off, with the possibility that a smaller number of building owners decide to implement more significant investments with a much longer payback period at an appropriate renewal point. In practice, there will be variability in uptake of energy efficiency investments across different building

[16] In our modelling, we also assumed new building stock are built with improved energy efficiency measures so do not incur the same upgrade costs as existing building stock. Refer to Appendix A for further detail on our assumptions.

[17] This is an adjusted proportion, based off a US study which carried out a cost-benefit analysis of large commercial buildings to find an average of 15% of annual energy savings could be achieved through re-commissioning of the buildings (Mills et al. 2004). Given the age of the study (with improvements in energy saving technology since) and the difference in building cohort between US and New Zealand, we scaled this rate down by applying our baseline rate of energy reduction (-0.3%) and taking into account the number of years since the study and the fact that some small investment may still be required.

types within market segments. To be conservative, the variation in different building types, including where there would be a reduced tendency for owners to upgrade, is reflected in part through our use of conservative average rates of energy reduction.

We conducted sensitivity tests for the payback period used to calculate the cost of energy efficiency upgrades. These reveal a relatively high degree of sensitivity to the payback period for the cost of efficiency upgrades for existing building stock.[18]

In our modelling, we have assumed the central payback period of three years for the efficiency upgrades. However, a payback period of one year for the upgrades makes the policy significantly net positive in NPV. In contrast, the extension of the payback period to five years increases the cost by approximately 70 per cent. This is shown in Table 6 below.

Table 6: Sensitivity test results for changes in payback period for energy efficiency upgrades

Payback period	One year	Three years (base)	Five years
NPV ($million)			
Total cost savings	$801	$801	$801
Total cost to business	$311	$827	$1,404
Total cost to government	$3.5	$3.5	$3.5
BCR	2.55	0.96	0.57
NPV	$487	-$29	-$606

We also conducted a test on the proportion of buildings able to undertake no-cost upgrades. In our base case, we assumed a proportion of 10 per cent of the existing building stock, an adjusted figure based off a 2004 US study of 150 existing buildings.[19] This shows a slightly less degree of sensitivity to the change in percentage of stock assumed to be able to achieve energy savings with no-cost upgrades, with a positive BCR achieved with a 15 per cent proportion.

[18] Our modelling assumes that metering and efficiency upgrades are included as standard inclusions in all new buildings after FY30 and thus do not contribute additional costs beyond this point.

[19] Refer footnote 17.

Table 7: Sensitivity test results for changes in the proportion of buildings able to undertake no-cost upgrades

Proportion of existing stock	0%	10% (base)	15%
NPV ($million)			
Total cost savings	$801	$801	$801
Total cost to business	$918	$827	$786
Total cost to government	$3.5	$3.5	$3.5
BCR	**0.87**	**0.96**	**1.02**
NPV	**-$117**	**-$29**	**$15**

2.4.2 Sensitivities on energy saving benefits

A test of our results reveals a relatively high degree of sensitivity to the level of EUI reduction (which drives energy use savings) from buildings that would be achieved as a result of the policy changes. We adjusted the rate of EUI reduction by ±50 per cent to test the impacts of changes to the efficacy of the efficiency upgrades on our modelling results. This is summarised in Table 8 below.

Table 8: Sensitivity test results for changes in the level of EUI reductions from policy implementation

Level of EUI reduction	50% lower rate of EUI reduction	Base case	50% higher rate of EUI reduction
Base rate of EUI reduction without efficiency upgrades	-0.31%	-0.31%	-0.31%
EUI reduction with efficiency upgrades	-1.00%	-1.68%	-2.36%
NPV ($million)			
Total cost savings	$386	$801	$1,216
Total cost to business	$827	$827	$827
Total cost to government	$3.5	$3.5	$3.5
BCR	**0.47**	**0.96**	**1.46**
NPV	**-$444**	**-$29**	**$385**

Our results show that the BCR drops significantly if the EUI reductions achieved by the policy are 50 per cent lower than our baseline, although a proportionate increase in BCR is also realised if the rate of reduction is 50 per cent higher than the base case.

This suggests that, separate to efficiency upgrade costs, it would not take a much greater EUI reduction rate to produce a positive quantified NPV/net benefits. Further, past studies using the more specific data available in relation to New Zealand office buildings have also identified net benefits in applying the policy to larger office buildings, suggesting that the building types covered by the policy may warrant further analysis when designing regulations.

2.4.3 Impacts for future analysis

There are a few areas of analysis that we were not able to interrogate further due to time and data limitations. These areas, outlined below, could be investigated in more detail through the development of the regulations. Importantly, implementation of the policies would allow for collection of the very data that would help to refine CBA analysis.

In terms of building types included in the proposed policy, we are cautious that the EUI and average floor area are both larger for industrial buildings than other building types, even though this total floor area may not be suitable for energy efficiency upgrades (as they are likely used for industry-specific purposes or equipment). It is possible that the industrial data as constructed in the model might overstate its impact. However, in earlier versions of our modelling, we did not see much of an effect when omitting the industrial building sector from the analysis.

In the time available, we were not able to identify more specific energy use or building stock information to use in the model. Our energy use figures came from MBIE electricity and gas use data, but we acknowledge these totals will be inclusive of energy use from industry processes which are likely to be specific and varied across industry sectors.[20] For instance, the Australian NABERS rating system has been gradually expanding into industrial building types, sector by sector, focussing on different groups of industrial buildings. NABERS has recently expanded into warehouses and cold stores.[21] If new or alternative data sources allow, future analysis could assess more granularly whether the inclusion of different industrial sectors (or even different parts of industrial buildings, such as the office part of a factory) in regulations would have different benefits.

Energy prices may also affect the results. However, how prices might change in the future will be complicated by how industries and different sectors respond to decarbonisation. It is possible that decarbonisation may lead to a large increase in demand for electricity which pushes energy prices up in the future. As mentioned in section 2.3.2.3, it could also be possible that mandatory EPRs reduce the demand for energy, delaying the need for the construction of new electricity infrastructure, but the effect of this on prices may be unclear. We have not been able to model the potential impacts of this with the time and information available, although we expect that if energy prices increased, this could increase benefits.

[20] Detail on our model inputs are in 5.Appendix A.

[21] https://www.nabers.gov.au/nabers-accelerate, accessed 18 August 2022.

3. Cost benefit analysis of waste minimisation plans

The proposed waste minimisation plan requirements generate a quantified NPV of $66 million between 2023 and 2050, with a BCR of 1.01. Included within this estimate is the quantified benefit associated with decreasing emissions by 11.7 $MtCO_2e$ over the period.

The result is highly sensitive to the material recovery costs that indirectly arise from this option, which, depending on assumption sources, could result in a range from -$1.5 billion to $1.8 billion given the volumes this applies to. However, we expect that material recovery costs would decrease as a result of additional demand from this policy.

The quantified NPV may also be larger if waste volumes reduce over the period to 2050 as a result of this policy, as may be expected based on certain findings in the literature.

Further, the quantitative NPV needs to be considered alongside the significant potential non-quantified benefits.

This section outlines the CBA approach and framework for the proposed waste minimisation plan (WMP) requirements and summarises the results.

3.1 Options for analysis

This cost benefit analysis compares the **Base Case** (the status quo) with the policy intervention:

- **Base Case:** no further changes to the Building Act or Waste Minimisation Act (while changes may be possible, they would need to be separately assessed and we would not wish to predict these). We assume the announced changes to the waste levy are implemented as announced.
- **Option 2c**: requirements introduced for WMPs from buildings owners when building or demolishing buildings (with associated penalties and infringement fees for non-compliance).

The analysis below focuses on comparing Option 2c with the Base Case.

For **Option 2c**, while we note the legislation is enabling, for the purposes of estimation we assume:

- WMP requirements are implemented from 2024, with implementation costs spread over 2024 and 2025. While the WMP may not in itself require waste minimisation actions to be implemented, we assume that the requirement to develop the plan will encourage people to consider these actions. We assume that indirect impacts related to diversion from landfill and associated costs and benefits ramp up from 2025 to 2030 (a full set of assumptions is in Appendix A).

- WMPs are required when a building consent is sought for new building work, and when demolishing a building. The requirements will apply to the demolition of all buildings, except those exempted through regulation. This means the requirements will apply to the demolition of detached buildings and building elements fewer than three storeys.
- Owners are subject to penalties and infringement fees if they intentionally do not:
  - provide a WMP when a building consent is sought or before carrying out demolition work as required by regulations,
  - make the WMP available onsite,
  - provide the WMP to those required under regulations, or
  - comply with their submitted WMP.
- A passive enforcement approach from MBIE and local authorities.

We note the WMP requirements aim to allow flexibility for different construction or demolition projects and local circumstances, particularly around each area's waste management facilities. The WMP will exist independently to the building consent process. A WMP will be required at the same time as a building consent application is submitted, although the consent's approval will not depend on the plan.

We separately consider the impacts on waste diversion from landfills to the impacts from changes to the waste levy. Appendix A provides further information on the assumptions used.

3.2 Our cost benefit analysis framework

We have modelled the costs and benefits of Option 2c relative to the Base Case based on the volume of waste diverted due to the implementation of WMPs. We used waste volume as the basis instead of the number of WMPs because of information difficulties around estimating WMP numbers and given the impacts relate more to the resulting impact on waste volumes. Further, there is recent existing literature that is relevant on the impact of other interventions (such as changes to the waste levy) on waste volumes that provide useful indicators.

3.2.1 Quantified cost categories

Table 9 summarises the costs of WMPs (Option 2c), relative to the Base Case.

Table 9: Quantitative cost categories for WMPs

Cost	Description	Relevant party
Direct costs		
Cost of implementing WMPs	The cost to implement regulations and provide guidance/training to territorial authorities, and the costs of monitoring and compliance for both MBIE and territorial authorities.	Mix of MBIE and territorial authorities

Indirect costs		
Material recovery cost of recycling and reuse	The labour costs of sorting material, costs of collecting (cost of additional skip bins used for transporting deconstruction waste), and the cost of reuse or recycling (e.g. additional processing). Note: incorporated in this cost is the direct cost of developing the WMP itself.[22]	Developer

The direct cost of WMPs to developers is incorporated within the indirect cost category of the material recovery cost associated with the recycling and reuse of materials. However, we note that Tran (2017) estimated costs at around $90,000 to develop a WMP for a project diverting 2,138 tonnes of construction and demolition (C&D) waste. This represented about 0.1 per cent of the overall costs of the project considered in this study. Further, we note that additional waste infrastructure investment has already been signalled in the sector and suggest that the material recovery costs already include the collection, sorting and reuse/recycling costs. As such, we have not separately modelled any additional infrastructure capital or operating costs to process and divert waste. We have not considered this as a specific sensitivity but note that if such costs were applicable, they would be small relative to the material recovery costs.

The values used to estimate the material recovery (indirect) costs are the mid-point of two sources: 1) a nation-wide CBA of C&D in schools by Tonkin + Taylor in 2021; and 2) a CBA of C&D of an Auckland housing development in 2019.[23] These vary considerably as shown in Table 13 and discussed further in the Appendix.

We also note that:

- Significant regional variation exists across the 78 Territorial Authorities. As the second source focuses on Auckland and the first source involves a study where five out of nine schools assessed were in Auckland, the mid-point values may over-weight the material recovery costs observed in Auckland. This is relative to the 40 per cent of national building consents that are from Auckland. We simply note this in the context of considering the results. However, future analysis could potentially adjust for labour costs outside Auckland.
- We have used the base values from the Tonkin + Taylor (2021) report as our smaller estimates for material recovery costs. However, these values could be even smaller if the costs only apply to a proportion of the material flows, as suggested in the report.
- Material recovery costs are not specifically modelled by material type but are separated by materials being recycled or reused. We understand that costs vary by material (e.g. sorting/processing costs for concrete are lower than glass, wood, and metals). However, the Auckland study estimates are calculated on an average cost per tonne of waste (looking across materials) and the separate cost for processing concrete noted in the nationwide study are factored in that estimate and therefore the mid-point values.

[22] While not separately reported in our analysis, we note that estimates of the cost of WMPs have been in the vicinity of $90,000, for a project with over 2,000 tonnes of C&D wate by Tran (2017).

[23] Rohani et al (2019) *Cost Benefit Analysis of Construction and Demolition Waste Diversion from Landfill – A case study based on HLC Ltd development in Auckland.*

3.2.2 Quantified benefit categories

Table 10 summarises the benefits of WMPs (Option 2c), relative to the Base Case.

Table 10: Quantitative benefits of WMPs

Benefit	Description	Relevant party
Indirect benefits		
Avoided landfill costs	Avoided transport costs to landfill and avoided landfill disposal costs	Developer
Avoided material costs	Avoided costs of timber, ferrous and non-ferrous metals, concrete/rubble, and glass.	Developer
Avoided negative externalities	Avoided cost of embedded emissions of recycled and reused timber, metal, concrete/rubble, and glass.	Developers/society
Other benefits	Avoided disamenity effects: noise, litter, odour	Community
	Avoided natural gas use from the use of incinerated timber	Users of timber for incineration

All key data, assumptions and modelling parameters are detailed in Appendix A. We have included the following materials in our modelling:

- Timber
- metal
- concrete/rubble
- glass.

Other C&D landfill waste not included in our modelling includes:

- plasterboard
- paper
- plastics
- putrescibles
- textiles
- rubber
- potentially hazardous materials.

Although there was insufficient data to include these other materials in our analysis, the material modelled represents over 87 per cent of C&D waste sent to class 1 landfill and 98 per cent of waste sent to class 2-4 landfill according to figures from Eunomia 2017 (and that range is broadly consistent with data from MfE's 13 August 2021 written evidence to the Environment Select Committee on reducing C&D waste going to landfill). While the avoided material costs for some of these other materials may be lower, we note that there are facilities that use recycled plasterboard for fertiliser production in New Zealand.

3.3 Quantified cost benefit analysis results for waste minimisation plans

Table 11: CBA results for WMPs in net present value ($ million)

	NPV ($million)
Costs	
Direct: Cost to implement and monitor WMPs	6
Indirect: Material recovery costs	4,814
Total costs	**4,820**
Benefits	
Indirect: Avoided landfill disposal costs	**2,377**
Indirect: Avoided material costs	**1,479**
Indirect: Avoided costs of embedded emissions	**724**
Indirect: Avoided disamenity cost of landfill	**195**
Indirect: Other benefits	**112**
Total benefits	**4,886**
NPV	**$66**
BCR	**1.01**

3.3.1 Distribution of quantified impacts

Figure 3 shows that the quantified costs are dominated by the indirect costs to developers associated with the recovery cost materials, which make up 99 per cent of costs. This estimate includes the direct costs to developers of developing WMPs. The vast majority of this are the costs associated with material recovery costs for recycling (given the assumed volumes recycled compared to those reused). In contrast to material recovery costs, the direct one-off costs to MBIE to implement the regulations and the direct ongoing costs to both MBIE associated with oversight and information management and to territorial authorities for compliance monitoring and enforcement together only represent 0.1 per cent of costs.

Figure 3: Distribution of quantified WMP costs

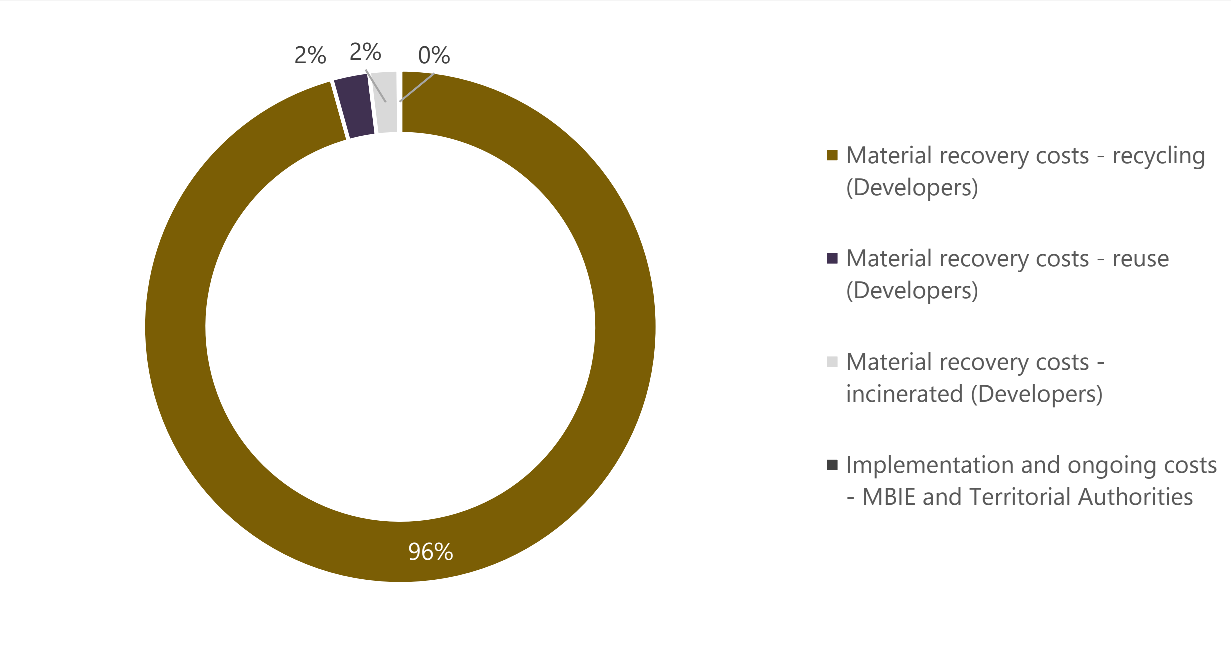
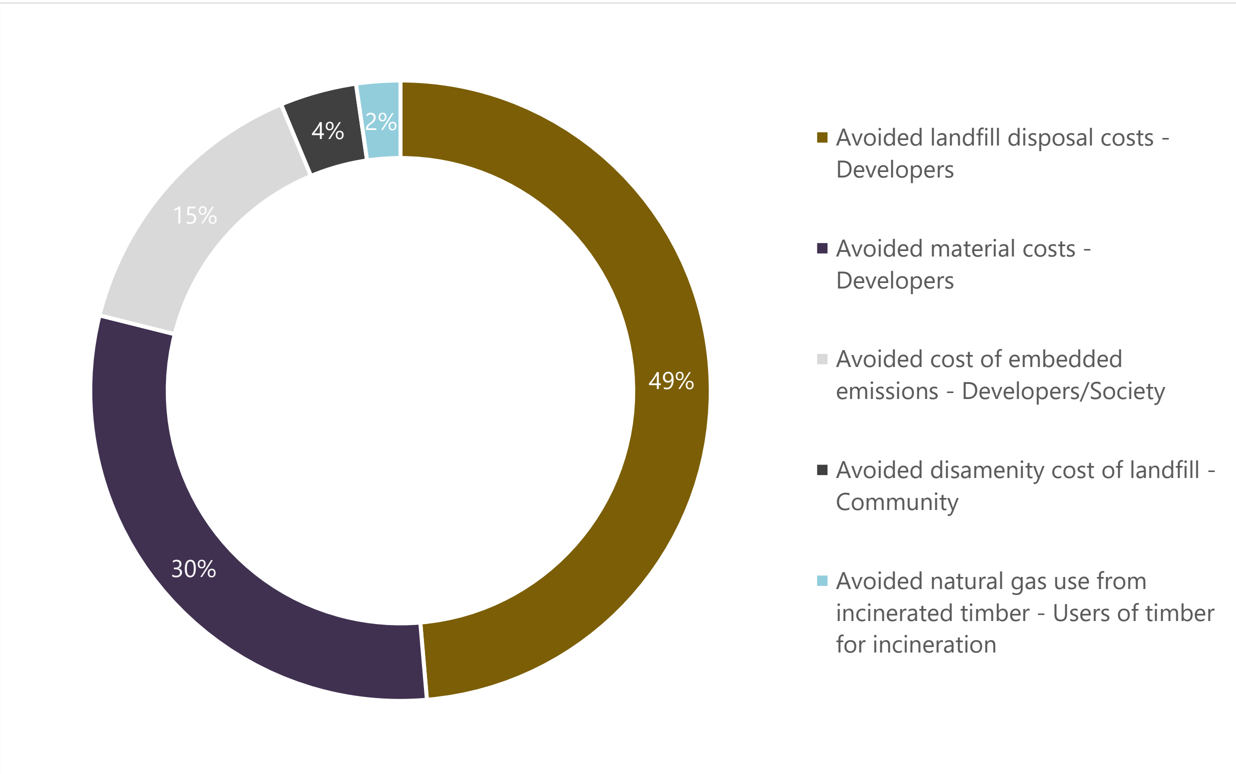


Figure 4 provides an overview of the quantified benefits of WMPs. Like costs, most benefits fall to developers. This includes the largest cost categories of avoided landfill costs ($2.4 billion) and avoided material costs ($1.5 billion). The avoided costs of emissions account for $724 million in present value terms, resulting from a modelled reduction of 11.7 $MtCO_2e$ over 2023-2050.

Figure 4: Distribution of quantified WMP benefits



3.3.2 Unquantified impacts

In addition to the quantified costs and benefits included in the analysis above, there are also a number of potential benefits from WMPs that we have not been able to quantify with the information and time available. These include the potential impacts of WMPs on:

- biodiversity, through reduced use of landfill and potential hazards surrounding landfill material and reduced impact on habitats resulting from greater reuse of materials that would otherwise be extracted from the natural environment
- reduced susceptibility of landfills to natural hazards such as floods relative to the Base Case where greater volumes of waste go to landfill
- economic opportunities resulting from expansion of the recycling industry and development of the market for the reuse of materials. While we have not included any potential job creation impacts in our CBA, we note that Rohani et al. (2019) cites studies by the United States Environmental Protection Agency (in 2002) and Institute for Local Self Reliance (in 2002) that estimate additional job creation from the recycling or waste recovery and reuse, with estimates from 1 (for incineration) to 296 jobs per 10,000 tonnes of waste recovered or reused.
- improved potential for reuse of landfill sites due to reduced potential health hazards, which would also improve associated land values
- reduced pollution to land, air and water from heavy metals and toxic chemicals.

Further, the following impacts were not quantified in our central estimate but are considered in the sensitivity analysis discussed in the next section. These are, to the extent that waste minimisation plans encourage designers to use less material or use material more efficiently in building designs, the resulting:

- reduced costs to building owners and developers, and
- reduced emissions from the extraction, manufacture and transportation of building materials.

3.4 Our analysis highlights the sensitivity to material recovery costs, time horizons and waste volumes

The above CBA results shows the key sensitivity for WMPs lies in material recovery costs and waste volumes that indirectly arise from this option. As a result, we report below the sensitivity to assumptions around cost, time horizon and volumes. We do not report other cost sensitivities and note that the largest cost category already reflects recent changes in landfill costs as a result of changes to the waste levy.

Future analysis when developing the regulations could consider sensitivities around material costs, the inclusion of additional materials if data becomes available, any changes if appropriate to assumptions around future carbon prices (or updates to emissions factors), or changes to gas prices. However, we focus on the most material factors for our results below.

Material recovery costs and time horizon

The NPV is highly sensitive to the material recovery costs, which, depending on assumption sources, could result in a range from -$1.5 billion to $1.8 billion given the volumes this applies to. We have taken the mid-point where there are different potential sources for inputs of material recovery costs.

We note that our analysis draws on past studies that have estimated these costs in New Zealand. However, the requirement for WMPs would be a significant policy change that is intended to support the market for the reuse and recycling of building materials. As a result, we expect material recovery costs may decrease as the market matures. Requiring a WMP will drive demand for material recovery services. This may encourage more businesses to enter, innovate and compete in the industry, and expand their geographic presence. In addition to increasing economies of scale, competition between suppliers may well decrease the material recovery costs over time.

We also note that there is greater uncertainty the further into the future that is modelled and without information on the number of WMPs, we have had to model impacts based on assumed changes in waste volumes (which reduced last year, we assume due to the change in the waste levy). As a result we have considered sensitivity to the time horizon modelled and note that NPV results reduce in magnitude if a shorter time horizon is used as shown in Table 12. The associated inputs for material recovery costs for the material cost scenarios is shown in Table 13 (note these are discussed further in Appendix A along with the other assumptions used). The results modelling out to 2030 turn negative over a shorter time horizon as there are fewer years where the benefits from increased diversion from landfill are considered (given the impact is only modelled to take full effect by 2030).

Table 12: WMP sensitivity analysis results for material recovery costs and time horizon

Material recovery cost scenario	2030 NPV (BCR)	2035 NPV (BCR)	2050 NPV (BCR)
Low	$258m (1.54)	$708m (1.56)	$1,836m (1.60)
Central	-$18m (0.98)	-$20m (0.99)	**$66m (1.01)**
High	-$259m (0.74)	-$655m (0.75)	-$1,474m (0.77)

Table 13: Material recovery cost input assumptions for sensitivity analysis

	Low	Central	High (original inputs)
Sorting – recycle	$26.41	$104.205	$182
Collecting	$48.30	$36.15	$24
Reuse	$33	$33	$33
Sorting – reuse	$26.41	$177.705	$329
Collecting	$48.30	60.65	$73
Reuse	$33	$33	$33
Processing concrete	$10	$10	$0

Waste volumes and time horizon

WMPs have the potential to reduce total waste volumes in New Zealand through better on-site management and/or designing out waste in the early development / planning stage. Evidence suggests that a large amount of waste (over a third) originates from poor design and management decisions (Llatas and Osmani, 2016).

We have modelled two scenarios:

1. A 10 per cent reduction in waste volumes due to better on-site management results in an NPV (BCR) of $537 million (1.12) in 2050. This better on-site management includes the WMPs' impact on reducing over-ordering, promoting reuse of materials on-site, or encouraging minimisation practices by sub-contractors. This is conservatively based on evidence found in a United Kingdom study where WMPs were associated with 15 per cent waste being generated.[24] No additional costs are modelled because on-site sorting costs are already factored into the estimated material recovery costs.

Figure 5: WMP sensitivity analysis results for on-site management and time horizon

Waste volume scenario	2030 NPV (BCR)	2035 NPV (BCR)	2050 NPV (BCR)
10% reduction of on-site waste	$55m (1.08)	$173m (1.10)	$537m (1.12)

2. A 15-25 per cent reduction in waste volumes due to better on-site management AND designing out waste in the early development / planning stage. This results in an NPV (BCR) between $108 million (1.02) and $657 million (1.16) in 2050. WMPs are expected to encourage developers to re-think and plan for managing waste. We assume this will incur additional costs for developers, not already factored into the estimated material recovery costs. The 15 per cent figure is consistent with the evidence referenced above (Llatas and Osmani, 2016) in relation to designing out waste, while the 25 per cent figure may apply if there were both a 15 per cent benefit from designing out waste and a 10 per cent benefit from better on-site management (considered separately above). Appendix A provides the method used to calculate the cost of designing out waste.

Figure 6: WMP sensitivity analysis result for on-site management, designing out waste, and time horizon

Waste volume scenario	2030 NPV (BCR)	2035 NPV (BCR)	2050 NPV (BCR)
15% reduction from designing out waste	-$12m (0.98)	-$3m (1)	$108m (1.02)
25% reduction from designing out and reduced on-site waste	$74m (1.11)	$222m (1.13)	$657m (1.16)

[24] WRAP (2008) Achieving Good Practice Waste Minimisation and Management: Guidance for construction clients, design team and contractors.

4. Unquantified impacts of information requirements and changes to purposes and principles

4.1 Information requirements

The proposed options include that MBIE may require certain information to be provided to it as set out in regulations. The impacts of seeking such a given set of information will be considered when determining what information is required. We have incorporated the impacts of this requirement as part of assessing the CBAs of WMPs and EPRs in terms of costs to:

- developers or building owners of providing information to MBIE (expected to be negligible given the information is already being provided elsewhere)
- MBIE to receive and maintain the information requested.

However, we also note that:

- if additional information is sought beyond these two areas as intended in the regulatory impact statement Option 3b, MBIE will need to consider the costs to those providing and receiving the information when this is considered in designing the associated regulations
- if MBIE were to publish this information, like it does in the register for earthquake prone buildings, this would bring additional IT costs (like the register) and reduce search costs in relation to EPRs and WMPs, which could improve compliance, energy efficiency and waste reduction.

4.2 Changes to purposes and principles

The changes to the purposes and principles in Option 3b involve the following changes to the Act:

- Amending one of the Act's purposes to focus on promoting emissions reduction and climate resilience.
- Introducing new climate change principles to the Act. The principles will be reorganised and contextualised in a modern climate change framework with principles proposed around the need to ensure that:
  - buildings minimise whole-of-life embodied carbon emissions
  - buildings have a high level of operational efficiency while having attributes that contribute appropriately to the health, physical independence, and well-being of the people who use them
  - buildings are built to be resilient to changing climate conditions.

We considered these changes in relation to Option 3b and as a package below.

4.2.1 Considerations for Option 3b

The changes to the purposes and principles are likely to result in greater:

- direct cost to implement the legislation (including drafting and consultation); for instance, a study in 2012 suggested that the average cost per page of legislation at the time was around $45,000[25]
- ease of adjusting settings as required to support climate objectives (reduced relative cost), where the 2012 study estimated the average cost of a new Act at the time was $3.3 million compared to the average cost of a new regulation of $0.5 million,[26] and
- certainty for the public around initiatives that may be introduced or progressed to meet emissions budgets.

4.2.2 Considerations for the package of changes as a whole

The incremental impacts of the proposed changes to the purposes and principles of the Act when combined with the inclusion of WMPs and EPRs may result in:

- improved compliance
- early and/or increased adoption (impacting costs and benefits)
- potentially increased enforcement (impacting costs and benefits).

Waste minimisation plans

The RIS associated with this proposal notes:

> The amendment [to the Act's purposes] will enable building work, building practitioners, and buildings' performance standards to be regulated to reduce emissions and ensure climate resilience. It will send a signal that the sector needs to consider climate change and the emissions implications of their decisions. As part of these changes, it will be clarified that they provide grounds for regulations in the Building Code to be created to reduce the operational and embodied carbon emissions of buildings.
>
> …
>
> This option [3b] will enable regulators of building work, building practitioners, and those implementing building performance standards to more predictably and consistently introduce policies, investments and changes in practice that will be required to reduce emissions and ensure buildings are climate resilient.

As a result, the impacts of WMPs may be more likely to occur sooner where Option 3b might be combined with Options 1c and 2c, as passing legislation could signal the need for the sector to move to this approach, encouraging earlier uptake. This may encourage greater emphasis from local

[25] See: https://www.otago.ac.nz/wellington/otago033080.pdf
[26] *Ibid*

authorities and a more rapid evolution of the market, which could decrease material recovery costs (which we note are the key driver of costs).

Energy performance ratings

In relation to EPRs, the proposed changes to the purposes and principles of the Act under Option 3b have the following potential incremental impacts (beyond those already considered in relation to Option 1c):

- Greater encouragement for investments in energy efficiency and resulting reductions in EUI. This would result in greater reduction in energy bills as well as greater costs associated with investments in energy efficiency, causing a net additional benefit.
- Possible impacts on enforcement efforts by territorial authorities, which could increase costs to these authorities but also improve compliance and resulting waste reduction, energy savings and wider benefits resulting from both.

5. Cost benefit analysis results for the package as a whole

> The proposed package of changes generates a quantified NPV of $37 million between 2023 and 2050, with a BCR of 1.00. However, as noted earlier, each component within this option is subject to numerous sensitivities that could result in net quantified benefits or in some cases costs.
> Further, the quantitative NPV needs to be considered alongside the non-quantitative benefits that have the potential to be significant. For instance, a review of the Australian commercial building disclosure programme estimated that total productivity benefits could increase the net benefits of the programme by 2 to 3 times. [27]

The results in Table 14 show the present value of total quantified costs and benefits of the whole package of changes (Options 1c, 2c and 3b) relative to the Base Case between 2023 and 2050, noting the significant additional non-quantified impacts identified in earlier sections would apply as well.

Appendix A outlines the detailed data and assumptions underpinning the analytical components.

Table 14: CBA results for package as a whole in net present value ($million)

	NPV ($million)
Costs	
Direct costs	
WMPs	6
ERPs	41
Indirect costs	
WMPs	4,814
EPRs	790
Total costs	**5,650**[28]
Benefits	
Indirect benefits	
WMPs	4,886
ERPs	801
Total benefits	**5,687**
NPV	**$37**
BCR	**1.00**

[27] *Commercial Building Disclosure Program Review*, ACIL Allen 2015, p57. This report found that total productivity benefits for the Australian programme were in the range of AU $110.5M to AU $167.8M but were excluded due to the lack of robust evidence.

[28] Note numbers do not add due to rounding.

References

Amitrano, L., Isaacs, N., Saville-Smith, K., Donn, M., Camilleri, M., Pollard, A., Babylon, M., Bishop, R., Roberti, J., Burrough, L., Au, P., Bint, L., Jowett, J., Hills, A., Cory, S., (2014). *Building Energy End-use Study (BEES), Part 1: Final Report*. BRANZ.

Centre for International Economics (CIE) (2019). *Independent review of the Commercial Building Disclosure Program*. https://www.cbd.gov.au/program/overview/cbd-2019-review

Chisholm et al. (2019). *What can we learn from Healthy Housing Initiatives? New Evidence from the Wellington Well Homes scheme*, https://blogs.otago.ac.nz/pubhealthexpert/what-can-we-learn-from-healthy-housing-initiatives-new-evidence-from-the-wellington-well-homes-scheme/

Energy Action and EnergyConsult (2018). *Mandatory Disclosure of NABERSNZ Rating for Office Buildings – Cost Benefit Analysis*. Energy Action (Australia) Ptd Ltd.

Eunomia (2017). *The New Zealand Waste Disposal Levy*, Eunomia. https://eunomia.co.nz/wp-content/uploads/2017/06/WDL-Final-Report-30-05-17.pdf

Gretton, G. & Pugliese, S. (2022), *Residential energy use in TIMES-NZ 2.0*. Energy Efficiency and Conservation Authority.

HEAL (2020), *HEAL Briefing: Healthy buildings, healthier people*. HEAL.

Hyder (2011). *Construction and Demolition Waste Status Report – management of construction and demolition waste in Australia*.

Institute for Local Self Reliance (2002). *Recycling means business*. https://ilsr.org/recycling-means-business/

Llatas, C., & Osmani, M. (2016). Development and validation of a building design waste reduction model. *Waste management*, 56, 318-336.

Mills, E., Bourassa, N., Piette, M. A., Friedman, H., Haasl, T., Powell, T., & Claridge, D. (2005, October). The cost-effectiveness of commissioning: a summary of a major study of 224 new and existing commercial buildings of various types. *Heating/Piping/Air Conditioning Engineering*, 77(10), 20+. https://link.gale.com/apps/doc/A138272346/AONE?u=vuw&sid=bookmark-AONE&xid=47ee9eff

Ministry of Health (2022). *Healthy Homes Initiative*, https://www.health.govt.nz/our-work/preventative-health-wellness/healthy-homes-initiative

Rohani, Huang, Hoffman, Ribeiro, & Roberts (2019). *Cost Benefit Analysis of Construction and Demolition Waste Diversion from Landfill – A case study based on HLC Ltd development in Auckland.*

Shahbazpour, Mehdi (2017). *Towards Zero Net Energy Schools*. BRANZ. https://d39d3mj7qio96p.cloudfront.net/media/documents/ER25_Towards_zero_net_energy_schools.pdf

Thinkstep (2018). *Under construction – hidden emissions and untapped potential of buildings for New Zealand's 2050 zero carbon goal.*

Tonkin + Taylor (2021). *Construction and Demolition Waste – Technical Report.*

Tran, V (2017). *Evaluating the Economics of Construction and Demolition Waste Minimisation and Zero Waste in the New Zealand Construction Industry.*

United States Environmental Protection Agency (2002). *Resource Conservation Challenge: Campaigning against waste.*

Appendix A CBA detailed assumptions

Common modelling parameters

Table 15: Common modelling parameters

Parameter	Value/ assumption	Rationale
Discount rate (real)	5%	New Zealand Treasury's recommended discount rate for regulatory proposals.
Modelling time frame	2023 - 2050	We assume that regulations are implemented from 2024, with implementation costs spread over 2024 and 2025 and impacts linearly increase over 5 years from 2025 as a transitional period. We model impacts to 2050 as this is the target timeframe for the reduction of net emissions to zero within the Zero Carbon Act.
Inflation rate	2%	Broadly representative of Statistics New Zealand's historic inflation data.

Energy performance ratings

Volume assumptions

Table 16: Volumes associated with mandatory energy performance ratings

Category	Description	Assumption / estimation
Volumes	Property stock – Commercial office	**869 buildings** **5,192,562 m^2** **0.7 %pa growth rate** From District Valuation Roll (DVR) data, supplied by Ministry of Housing and Urban Development (HUD). These are the buildings classified as Commercial Office minus the total estimate of public office buildings as estimated by EnergyAction and EnergyConsult in the 2018 CBA. Growth rate estimate from the Energy Action and EnergyConsult (2018) CBA.
	Property stock – Commercial retail	**1,234 buildings** **7,012,236 m^2** **0.7%pa growth rate** From DVR. We have followed the same broad grouping of "retail" used in the Building Energy End-use Study (BEES) of commercial buildings in New Zealand, led by BRANZ (Amitrano et al., 2014)[29] as we take the estimate for retail EUI from the BEES research. Due to data and time constraints, we assume the same growth rate as that for commercial offices.

[29] https://www.branz.co.nz/environment-zero-carbon-research/bees/.
Building Energy End-use Study (BEES) was a 6-year research project looking at energy and water use in NZ commercial buildings, which ran from 2007. "Retail" included DVR codes of CL, CM, CR, CS, ST, CV, CX.

Category	Description	Assumption / estimation
	Property stock – Commercial non-office non-retail	**1,966 buildings** **13,166,440 m²** **0.7 %pa growth rate** From DVR. Due to data and time constraints, we assume the same growth rate as that for commercial offices.
	Property stock – Public non-offices	**1,829 buildings** **11,210,310 m²** **0.6 %pa growth rate hospitals** **0.1%pa growth rate schools** From DVR, using the classifications of property types classified as "Other Education" and "Other Health". The current proposal is for public buildings to be captured in the regulations. Given time and data limitations, we have focussed the analysis on hospitals and schools, which we consider to be the main buildings likely to be over 2000m². Public offices were excluded, as government offices are already subject to energy performance reporting requirements. Data on specific public building types, stock and area, was limited. We were not able to separate buildings that are publicly or privately owned. We considered the DVR source was more appropriate than alternative data sources available, such as LINZ data, which appeared likely to produce a significant undercount. That source enabled us to estimate building footprints, but not total area, and did not enable identification of private or public buildings. While the DVR could be filtered for "government-owned" buildings, the estimates appeared highly inaccurate. This is, likely because many buildings for public use such as schools and hospitals are owned by different entities in the wider public sector. Growth rates are based on the growth rate of the number of hospital beds in NZ based on OECD estimates, and growth rate of count of schools in New Zealand.
	Property stock – Industrial	**7,889 buildings** **37,956,573 m²** **0.7 %pa growth rate** From DVR. Due to data and time constraints, we assume the same growth rate as that for commercial offices.
	Property stock – Large-scale residential	**1,285 apartment buildings** **4,259,522 m²** **0.7%pa growth rate** From DVR. Due to data and time constraints, we assume the same growth rate as that for commercial offices.

Quantified costs assumptions

Table 17: Quantified costs associated with mandatory energy performance ratings

Cost category	Cost description	Cost assumption / estimation
Rating costs (cost to building owners)	NABERSNZ first assessment and certification	**$4,000 per rating — base case** **$3,000 per rating — mandatory scheme** Average value based on information from NABERSNZ.[30] In the case where ratings are mandatory, we assume fees are lower to represent increased competition in the market for assessors. This is based on information from NZGBC and follows the approach from the Energy Action CBA (Energy Action and EnergyConsult, 2018).
	NABERSNZ subsequent assessment	**$2,800 per re-rating — base case** **$2,100 per re-rating — mandatory scheme** We assume the initial rating will involve relatively more data collection and that subsequent ratings will accordingly be lower in cost. We have applied a 30% discount, based on information from NZGBC.
	Frequency of ratings	**Every 3 years** We assume buildings are required to be rated every three years. We have based this on current requirements for government office buildings to be re-rated every three years where they do not meet the required target rating.[31] This is comparable to the requirement of a full re-rating every four years that the United Kingdom government has proposed in its regulations.[32]
Metering costs (cost to building owners)	Upgrades for buildings with insufficient metering	**$1.73/m²** Average costs based on the estimate in the Energy Action and EnergyConsult CBA (2018) (adjusted for inflation), originally estimated from a NZGBC assessment of a sample of 10 office buildings. We assume this cost is a one-off and is required for 50% of existing office non-industrial building stock (excluding apartments given they are likely to already to have unit-level metering). We also assume that from FY31 onwards the required metering is standard in new building stock and no metering upgrades are required.
Energy efficiency upgrade costs (cost to building owners)	Investment in efficiency upgrades (commercial/	**$10.81/m² –** commercial (offices) **$9.80/m²** – commercial (retail and other) **$6.01/m²** – large-scale residential **$11.88/m²** – public buildings

30 https://www.nabersnz.govt.nz/how-to-get-a-rating/assessment-costs/, accessed 5 August 2022.

31 https://www.procurement.govt.nz/property/lease-and-facilities-management/energy-efficient-buildings/, accessed 5 August 2022.

32 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970368/performance-based-policy-framework-office-impact-assessment.pdf, accessed 5 August 2022.

Cost category	Cost description	Cost assumption / estimation
[Indirect cost]	public/industrial/ large-residential)	**\$20.62/m²** – industrial We estimate an average cost of investment in efficiency upgrades per square meter for each type of building based on the approach taken in the previous CBA by Energy Action and EnergyConsult (2018), but with our updated property stock, energy usage and tariff rates. We assume the energy efficiency upgrades have a useful life of 10 years. This approach assumes that building owners implement an investment that equates to the amount of energy savings over an average three-year simple payback period (following earlier work informed by discussions with EECA). This may be a conservative estimate that could overestimate the costs of upgrades as there are many measures that building owners could take without significant costs, such as programming heaters to turn off overnight, or ensuring even temperatures are maintained. The Energy Action and EnergyConsult (2018) CBA also notes that the three-year average payback is more conservative than the 2.5 year payback used in the 2009 study examining the feasibility of a NABERSNZ scheme.[33] As with metering costs, we have assumed that these costs apply to existing stock and not to new building stock which is likely to be built with improved energy efficiency measures.
	Electricity tariff	**0.185 \$/kwh – commercial** **0.171 \$/kwh – industrial** **0.306 \$/kwh – residential** Based on the prices in the Climate Change Commission's July 2022 report on the unit limit and price control settings of the New Zealand Emissions Trading Scheme.[34]
	Gas tariff	**0.066 \$/kwh – commercial** **0.032 \$/kwh – industrial** **0.147 \$/kwh – residential** As above, based on the prices in the Climate Change Commission's July 2022 report.[35]
Implementation (cost to government)	Policy implementation to embed new regulations	**\$500,000** for first two years We follow the Energy Action and EnergyConsult (2018) CBA and assume MBIE incurs a one-off implementation cost of \$500,000. We assume this is split between the first two years.
	Ongoing monitoring,	**\$219,000 per year**

[33] Cited in Energy Action and EnergyConsult (2018): Study of non-residential building energy rating schemes (BERS), Concept Consulting, 2009.

[34] https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/ETS-advice-July-22/PDFs/NZ-ETS-settings-2023-2027-final-report-web-27-July-2022.pdf, accessed 8 August 2022.

[35] https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/ETS-advice-July-22/PDFs/NZ-ETS-settings-2023-2027-final-report-web-27-July-2022.pdf, accessed 8 August 2022.

Cost category	Cost description	Cost assumption / estimation
	compliance, and enforcement costs	We assume a light compliance function with 5 FTE and 50% on-cost loading. Based on the average annual salary of $87,600 for a public service employee.[36]

Quantified benefits assumptions

Table 18: Quantified benefits associated with mandatory energy performance ratings

Benefit category	Benefit description	Benefit assumption / estimation
Reduced energy bills	Energy use intensity (EUI) – Commercial office	**239 kwh/m²** Weighted average EUI based data from the BRANZ BEES report (Amitrano et al., 2014).
	EUI – Commercial retail	**216 kwh/m²** 176 kwh/m² electricity 40 kwh/m² gas Total energy consumption from Table C of BRANZ report (Amitrano et al., 2014). Proportions of energy use estimated from MBIE energy consumption data.
	EUI – Commercial non-office, non-retail	**216 kwh/m²** 176 kwh/m² electricity 40 kwh/m² gas Assume same electricity and gas use proportions as commercial retail, due to data limitations.
	EUI – Public non-offices (hospitals)	**466 kwh/m²** 379 kwh/m² electricity 87 kwh/m² gas Based on estimates of hospital EUI from the iHub report on healthcare sector building and cooling cites of between 466-550 kWh/m2 in Scotland and the UK,[37] and between 393-467 kWh/m2 in Australia between capital cities and regional locations. An article from Build Magazine states that average for a New Zealand hospital is 360kwh/m2/year. As we could not identify the source of this, we opted not to use it.[38] Due to data and time constraints, we assume the electricity and gas use proportions as that for commercial.
	EUI – Public non-offices (schools)	**213 kwh/m²** 174 kwh/m² electricity

[36] https://www.publicservice.govt.nz/our-work/workforce-data/remuneration-pay/wage-trends/, accessed 8 August 2022.
[37] https://ihub.org.au/wp-content/uploads/2020/06/LLHC1_Healthcare_Sector_Baseline_Energy_Report_V01.pdf
[38] https://www.buildmagazine.org.nz/index.php/articles/show/green-hospital-a-healthier-choice

Benefit category	Benefit description	Benefit assumption / estimation
		39 kwh/m² gas Average energy use estimated from Towards Zero Net Energy Schools report for BRANZ (Shahbazpour, 2017). Electricity and gas use proportions assumed the same as commercial retail, due to limited availability of more specific data on energy usage in different public buildings.
	EUI – Industrial	**746 kwh/m²** 362 kwh/m² electricity 384 kwh/m² gas Estimated from MBIE total energy consumption for industrial users,[39] divided by the estimate for industrial property stock from DVR data. This number will be inclusive of energy use from industry processes which are likely to be specific and varied.
	EUI – Large-scale residential	**87 kwh/m²** 11 kwh/m² electricity 76 kwh/m² gas Estimated from the EECA TIMES report (Gretton and Pugliese, 2022) for joined dwellings and average dwelling size (115m²). Proportions estimated from MBIE energy consumption for residential user group.[40]
	Baseline change in EUI over time – non-industrial	**-0.3% pa** We have adjusted and scaled down the baseline change in EUI over time that was used in the Energy Action and EnergyConsult (2018) CBA (-0.5%) by the base building/total building ratio from their CBA as we consider whole building rather than base building energy. We note that energy intensity in New Zealand overall, as measured in terms of how much energy is required to produce a unit of GDP, is decreasing on average (1.4% between 1990-2019).[41] However, we were not able to find an equivalent parameter to use for the change in efficiency upgrades for businesses that implemented efficiency upgrades. For consistency and the purposes of tractability of modelling, we opted to use both figures from the 2018 CBA (Energy Action and EnergyConsult).
	Baseline change in EUI over time – industrial gas	**-2.4% pa** Based on MBIE Energy data 2017-21 multiplied by ratio of base building EUI to total building EUI from Energy Action and EnergyConsult CBA (2018).

[39] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/ and https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/gas-statistics/
[40] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/ and https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/gas-statistics/
[41] https://www.mbie.govt.nz/dmsdocument/16820-energy-in-new-zealand-2021, accessed 18 August 2022.

Benefit category	Benefit description	Benefit assumption / estimation
	Baseline change in EUI over time – industrial electricity	**-1.6% pa** As above.
	Change in EUI of businesses that implemented efficiency upgrades	**-1.68% pa** Average of ratio of base building EUI/total building EUI for buildings over 1500m2 from the 2018 CBA (53%), applied to the -3.0% used by Energy Action and EnergyConsult (2018).
	Change in EUI of industrial businesses that implemented efficiency upgrades for gas	**-3.76% pa** Based on the achieved difference between commercial buildings that did and did not implement energy efficiency upgrades (~1.5%) added to the baseline change in industrial usage of gas.
	Change in EUI of businesses that implemented efficiency upgrades for electricity	**-3.0% pa** Based on the achieved difference between commercial buildings that did and did not implement energy efficiency upgrades (~1.5%) added to the baseline change in industrial usage of electricity.
Reduced carbon emissions	Reduced carbon emissions	Calculated as the total reduction in energy usage in kWh x emissions factors x carbon price.
	Emissions factors	**0.107 kgCO2/kwh – electricity** **0.195 kgCO2/kwh – gas** Average emissions factors published by the Ministry for the Environment.[42]
	Carbon price	Avoided emissions are multiplied by the NZ Treasury's shadow carbon price (real): **$96** in 2023, rising to **$174** in 2050.
Proportion and timing assumptions	Proportion of office buildings and large apartments which voluntarily report energy usage and actively seek to reduce energy usage	**8.0%** Based on estimates from the EnergyAction and EnergyConsult (2018) CBA, which was the rate assumed to be achieved by 2018. We assume that this will hold for commercial offices and large residential, as some of these buildings will have an incentive to voluntarily report and reduce their energy usage to achieve better prices/value.
	Proportion of public non-office and commercial - retail and other which voluntarily report energy usage and actively seek to reduce energy usage	**2.0%** We assume significantly less demand for buildings to voluntarily uptake and reduce usage across non-office and residential buildings, as these buildings have fewer commercial drivers for voluntary energy usage reductions.
	Proportion of office non-industrial buildings needing metering upgrades	**50%** Based on estimates from the EnergyAction and EnergyConsult (2018) CBA, which assumed that half of the existing building stock would need metering upgrades to enable energy usage upgrades.

[42] https://environment.govt.nz/publications/measuring-emissions-a-guide-for-organisations-2022-summary-of-emission-factors/

Benefit category	Benefit description	Benefit assumption / estimation
	Timeframe to standard inclusion of energy usage technology	**FY30** Our modelling assumes that metering and efficiency upgrades are included as standard inclusions in all new buildings after FY30 and thus do not contribute additional costs beyond this point.
	Proportion of buildings that can achieve energy use reductions with no-cost upgrades	**10%** This is an adjusted proportion, based off a US study which carried out a cost-benefit analysis of large commercial buildings to find an average of 15% of annual energy savings could be achieved through re-commissioning of the buildings (Mills et al. 2004). Given the age of the study (with improvements in energy saving technology since) and the likely differences in building cohort (the existing buildings in the US study had a median size of around 14,000 m2), we scaled this rate down by applying our baseline rate of energy reduction (-0.3%) and taking into account the number of years since the study.

Waste management plans

Modelled volumes

Estimating total construction and demolition waste that could be additionally diverted

Diverted C&D waste includes waste that is recycled or reused. We estimate these volumes as a result of policy intervention by subtracting C&D waste that would be diverted in business as usual (BAU) from C&D waste that could be diverted from further recycling and reuse efforts as a result of WMPs. Based on C&D recovery data from Eunomia (2017), we focus on timber, concrete/rubble, glass, ferrous and non-ferrous metals diverted from all landfills.

We use 2015 data from Eunomia (2017) to estimate C&D waste volumes, assuming waste volumes grow at the same rate as real GDP. The following table presents the data for 2020. We assume no change until 2022, 1 per cent growth in 2023 and 2.2 per cent growth p.a. from 2024.

Table 19: Composition of C&D waste, 2020 (tonnes)

Category	Class 1 landfills	Class 2-4 landfills	Total diverted
Paper	16,008	2,705	0
Plastic	20,934	0	0
Putrescibles	16,624	43,285	0
Ferrous metal	**29,554**	**2,705**	**53,179**

Category	Class 1 landfills	Class 2-4 landfills	Total diverted
Non-ferrous metal	**2,463**	**0**	**4,042**
Glass	**9,236**	**0**	**4,254**
Textiles	19,087	0	0
Sanitary paper	616	0	0
Rubble and concrete	**241,358**	**2,405,017**	**1,099,318**
Timber	**253,672**	**248,888**	**151,477**
Rubber	4,926	2,705	0
Potentially hazardous	3,079	0	0

Source: Sapere estimates based on Eunomia (2017)

The table below provides the assumptions we used on BAU and maximum future diversion rates. The difference between the two scenarios indicates the maximum volumes of C&D waste that could be additionally diverted as a result of policy intervention. We assume the maximum potential can be achieved from 2030, with a linear ramp-up until then.

Table 20: Assumptions on BAU and future C&D waste diversion rates

Category	BAU	Future (max potential) from 2030
Timber – total	23% Source: estimated based on data in Eunomia (2017)	75% Source: ThinkStep (2018) Under Construction (p.18)
Timber - reused	5% Source: BRANZ Building end of life module C1 xls	15% Source: BRANZ Building end of life module C1 xls
Timber – recycled	10% Source: BRANZ Building end of life module C1 xls	30% Source: BRANZ Building end of life module C1 xls
Concrete/rubble - recycled	20% Source: BRANZ Building end of life module C1 xls	90% Source: BRANZ Building end of life module C1 xls
Ferrous and non-ferrous metals – recycled	62% Source: estimated based on data in Eunomia (2017)	89% Source: ThinkStep (2018) Under Construction (p.18)
Glass	32% Source: estimated based on data in Eunomia (2017)	50% Source: ThinkStep (2018) Under Construction (p.18)

Attributing diversion of construction and demolition waste volumes to policy intervention

Option 2c is a high-level policy intervention, and at this stage we are not able to assess the specific outcomes expected from the implementation of these policy interventions. Further, the expected increase in waste levies[43] may also be a contributing factor to increased diversion rates.

To isolate the impact of the waste levy, we assume a price elasticity of -0.23, which is the mid-point value assumed in NZIER (2021). The volumes that are additionally diverted away from landfills as a result of the increased levies are then subtracted from the maximum additional waste diversion that can be achieved through higher recovery rates as per Table 20.

Different waste diversion objectives set out in individual WMPs will results in different outcomes. Further, we expect the full package to deliver higher diversion rates than Option 2c alone because inclusion of climate change objectives in the purposes and principles is likely to provide a greater signal around the expected behaviour change in the construction sector. However, given the extent is difficult to quantify, we do not present differences between these options.

Hyder (2011) provide case studies of the C&D sector in Australia, noting that the Government's proactive support in South Australia and ACT of recycling and resource recovery contributed to over 75 per cent of all C&D wase material being recycled in those states.[44] We have conservatively assumed that 75 per cent is the highest rate that could be achieved for our analysis. The maximum diversion rates from Table 20 yield an aggregate recycling rate of 85 per cent for the given materials.[45] We have therefore scaled down the assumed diversion (keeping relative weightings of respective materials) to not exceed 75 per cent overall.

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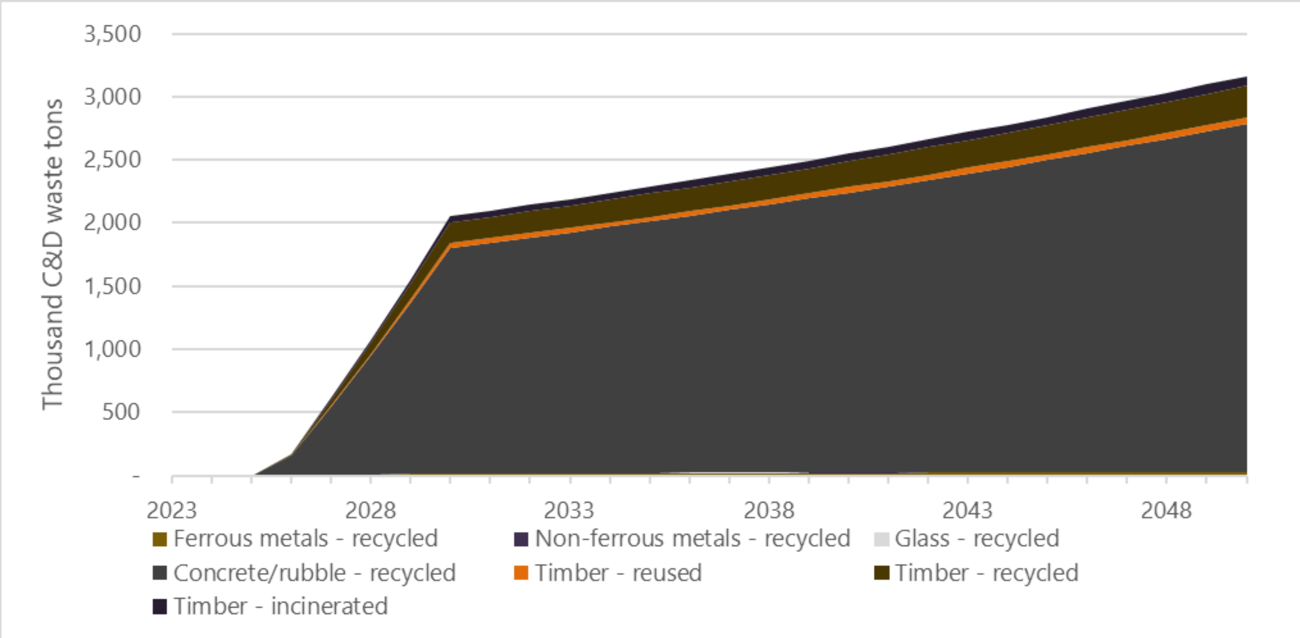
[43] https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/waste-disposal-levy/expansion/

[44] P.148 in Hyder (2011) Construction and demolition waste status report

[45] This was estimated using the relative weights of the given material.

Figure 7: Estimations of C&D waste volumes additionally diverted



Source: Sapere analysis.

Quantified costs assumptions

Table 21: Quantified costs associated with mandatory waste minimisation plans

Cost category	Cost description	Cost assumption / estimation
Material recovery cost – recycling	Labour cost of sorting material	**Latest scenario – $26.41/tonne diverted** **Central scenario - $104.21/tonne diverted** **Original scenario - $182/tonne diverted** The latest value is based on table 5.1 from Tonkin + Taylor (2021) report. It is the sum of off-site sorting cost ($25/tonne) and an estimate weighted average of $1.41/tonne for on-site sorting. The assumption in the original scenario is based on table 16 in Rohani et al (2019). The central assumption is an average between the original and latest values.
	Cost of collecting – cost of additional skip bins used for transporting deconstruction waste	**Latest scenario - $48.3/tonne diverted** **Central scenario - $36.15/tonne diverted** **Original scenario - $24/tonne diverted** The latest value is based on table 5.1 from Tonkin + Taylor (2021) report. The original is based on Rohani et al (2019) that considers a collection cost of $0 to $1200 per dwelling. These are converted to a tonnage rate based on the ratio of new and altered consents, yielding a range of $24 to $73/tonne for recycling and reuse. The updated value is the average between $24 and $73. The

Cost category	Cost description	Cost assumption / estimation
		central scenario is the average between the original and latest values.
	Cost of reuse – additional expenses related to reuse (e.g. additional processing)	**$33/tonne diverted** Rohani et al (2019), p. 57
Material recovery cost – reuse	Labour cost of sorting material	**Latest scenario – $26.41/tonne diverted** **Central scenario - $177.71/tonne diverted** **Original scenario - $329/tonne diverted** The latest value is based on table 5.1 from Tonkin + Taylor (2021) report. It is the sum of off-site sorting cost ($25/tonne) and an estimate weighted average of $1.41/tonne for on-site sorting. The assumption in the original scenario is based on table 16 in Rohani et al (2019). The figure in part reflects greater effort in deconstruction rather than demolition, which is why it is larger than the recycling figure. The central assumption is an average between the original and latest values.
	Cost of collecting – cost of additional skip bins used for transporting deconstruction waste	**Latest scenario - $48.3/tonne diverted** **Central scenario - $$60.65/tonne diverted** **Original scenario - $73/tonne diverted** The latest value is based on table 5.1 from Tonkin + Taylor (2021) report. The original is based on Rohani et al (2019) that considers a collection cost of $0 to $1200 per dwelling. These are converted to a tonnage rate based on the ratio of new and altered consents, yielding a range of $24 to $73/tonne for recycling and reuse. The higher cost for reuse reflects more destinations that the waste is sent to for further processing. The updated value is the average between $24 and $73. The central scenario is the average between the original and latest values.
	Cost of reuse – additional expenses related to reuse (e.g. additional processing)	**$33/tonne diverted** Rohani et al (2019), p. 57
	Cost of processing concrete (crushing)	**10/tonne diverted** Table 5.1 in Tonkin + Taylor (2021)
Cost of implementing WMP	One-off cost to MBIE to implement regulations and BCAs/MBIE: training costs	**$500,000 in 2024** Based on Sapere's CBA proposed building systems regulations (2021), p. 46 and scaled up to reflect this is at the stage of primary legislation with associated regulations needed as well and an estimate for the need for guidance/training.
	Ongoing cost to MBIE	**$395,613 p.a.**

Cost category	Cost description	Cost assumption / estimation
		3 FTE + 50% for overheads. Average annual salary for public service employees FY22 - $87,914
	Cost of designing out waste (used in sensitivity analysis)	**$29.63/tonne** Case study 1 in Tran (2017) indicates a cost of $57,375 for a project diverting 2,138 tonnes of C&D waste. This is the adjusted for 2022 dollars using an inflation rate of 2%.

Quantified benefit assumptions

Table 22: Quantified benefits associated with mandatory waste minimisation plans

Benefit category	Benefit description	Benefit assumption / estimation
Avoided landfill costs	Avoided landfill disposal costs	**$75.27/tonne diverted from landfill** CBAx values for landfill disposal costs are: $129/t - Municipal landfill (class 1) $63/t - construction and demolition fill $43/t - managed fill and controlled fill (class 3 and 4) Weighted for volume of applicable classes for C&D from Eunomia 2017. Waste levy expansion: $60, $30, $20 from 2024 for each class respectively.[46]
	Avoided transport costs to landfill	**$15/tonne diverted** Based on previous Sapere analysis. We assume waste would go from a C&D site directly to landfill or pass through a transfer station and then to landfill. With the WMP, waste would go from site to the RRC or another build site, with a residual going to landfill. Tran (2017) used an average distance to landfill of 60km. Expert opinions on the unit cost of transporting C&D waste between the project sites and landfill range between $30 and $40 per tonne (Rohani et al., 2019). Recent freight analysis puts transport costs at $1.9 per/km with fixed and labour costs added rates range from $3-$6per/km. Using the 60km estimate produces a range of $180-$360 for a Twenty-foot Equivalent Unit (TEU). Assuming 20 tonnes per TEU the cost could be in the $9 to $18 range. We use the lower end of expert opinion $30 per tonne and simply assume costs halved in RRP scenario meaning there is a $15 per tonne saving.

[46] https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/waste-disposal-levy/expansion/#:~:text=The%20waste%20disposal%20levy%20expansion,tonne%20as%20of%20July%202024.

Benefit category	Benefit description	Benefit assumption / estimation
Avoided material costs	Avoided cost of timber	**$455/tonne diverted** Evidence from Community Recycling Centres suggests $1 per metre. To convert from tonnes to cubic metres we use an online calculator for radiata pine that suggests for dry timber there is 0.44 tonnes to a cubic metre. Redstag timber conversion tables for 100 by 50 wood suggest this would convert to around 455 linear metres per tonne. This is an underestimate as it excludes timber of higher value salvage (e.g. native timber retail for around $5-$10 a metre)
	Avoided cost of ferrous metal	**$250/tonne diverted** This figure is based on advertised prices paid for roofing iron of $200-300 by scrap merchants.
	Avoided cost of non-ferrous metal	**$1000/tonne diverted** Based on NZIER (2021).
	Avoided cost of concrete/rubble	**$11.3/tonne diverted** Assumed to be crushed into aggregated. Prices from https://roadmetals.co.nz/wp-content/uploads/2021/06/WaimakQuarry_PriceList_2021.pdf
	Avoided cost of glass	**$75/tonne diverted** Based on NZIER (2021).
Avoided negative externalities	Avoided cost of embedded emissions – recycled timber	**0.3113tCO2e/tonne diverted** This is the estimate for embedded emissions in recycled and primary material production of wood, as per United Kingdom Government GHG Conversion Factors for Company Reporting.
	Avoided cost of embedded emissions – reused timber	**0.31tCO2e/tonne diverted** This is the estimate for embedded emissions in primary material production of wood, as per United Kingdom Government GHG Conversion Factors for Company Reporting. Avoided emissions are then multiplied by the New Zealand Treasury's shadow carbon price (real): $96 in 2023, rising to $174 in 2050.
	Avoided cost of embedded emissions – incinerated timber	**1.08tCO2e/tonne diverted** This is the estimate for replacing combustion of natural gas with incineration of timber. Assumes that the emissions factor for natural gas is 0.0541 tCO2e/GJ (using the Ministry for the Environment's emissions factors), and the energy content of pine is 20 GJ/tin (based on EECA data). Avoided emissions are then multiplied by the New Zealand Treasury's shadow carbon price (real): $96 in 2023, rising to $174 in 2050.
	Avoided cost of embedded emissions	**0.13tCO2e/tonne diverted**

Benefit category	Benefit description	Benefit assumption / estimation
	– recycled concrete/rubble	This is the estimate of embedded emissions in primary material production of concrete, as per United Kingdom Government GHG Conversion Factors for Company Reporting. Avoided emissions are then multiplied by the New Zealand Treasury's shadow carbon price (real): $96 in 2023, rising to $174 in 2050.
	Avoided cost of embedded emissions – metal	**3.86tCO2e/tonne diverted** This is the estimate of embedded emissions in the primary material production of metals, as per United Kingdom Government GHG Conversion Factors for Company Reporting. Avoided emissions are then multiplied by the New Zealand Treasury's shadow carbon price (real): $96 in 2023, rising to $174 in 2050.
	Avoided cost of embedded emissions – glass	**1.18tCO2e/tonne diverted** Based on BRANZ CO_2NSTRUCT values for embodied greenhouse gas and energy for a range of construction material and products. Avoided emissions are then multiplied by the New Zealand Treasury's shadow carbon price (real): $96 in 2023, rising to $174 in 2050.
Other benefits	Avoided use of natural gas – timber incinerated	**$177.80/tonne** Saving in the cost of natural gas compared to using salvaged timber. Natural gas price is $0.032/kWh and $8.89/GJ. The energy content of dry timber (pin) is 20GJ/tonne. Therefore, the money saved from incinerating timber is $177.80/tonne.
	Avoided disamenity effects: noise, litter, odour	**$7.41/tonne** Inflating the average of the lower and upper bounds to 2022 dollars from: https://environment.govt.nz/assets/Publications/Files/nzier-waste-levy-extension.pdf

About Sapere

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