Sustainability Planning Amendment – Cost Benefit Analysis

Council Alliance for a Sustainable Built Environment

27 | 07 | 2023

SGS Economics & Planning

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Executive summary

SGS Economics and Planning (SGS) was commissioned by the MAV on behalf of CASBE to prepare a cost benefit analysis (CBA) of the proposed Planning Scheme Amendment (the Amendment).

The proposed Amendment aims to increase sustainability standards in new buildings and significant alterations to existing buildings through the planning process, to ensure that they are adapted to a changing climate and mitigate carbon emissions that are impacting the climate. The changes proposed by the Amendment include building structural changes, switching away from gas and choosing energy efficient appliances to speed the transition to green energy and reduce overall energy use; to support sustainable transport options such as active travel and electric vehicles, to promote the reuse and recycling of building materials and waste in operational buildings, to reduce potable water use, improve airflow and indoor environmental quality and establish green infrastructure (trees, green roofs, shrubs and so forth).

At present, different Councils have different environmental standards. Some Councils have implemented planning requirements for Environmentally Sustainable Development (ESD) and others have not. The proposed Amendment would result in greater standards of energy efficiency, resource efficiency and sustainability than current ESD standards (for Councils that have them).

The changes from the Frontier Economics analysis

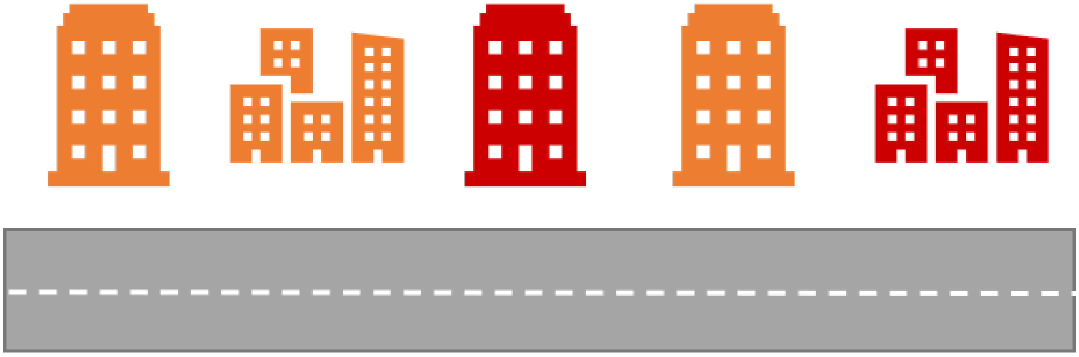
This analysis is an update of a similar CBA prepared by Frontier Economics in March 2022. That analysis considered the impact of the Amendment on several hypothetical residential and non-residential building typologies, and compared the increased construction costs, changes in energy use and so forth against the benefits of reduction in carbon emissions, reduced overall energy use and so forth.

The key difference in SGS' analysis is that instead of focusing on the impacts of individual hypothetical buildings, we also considered the impacts at the neighbourhood level. With the Amendment, neighbourhoods slowly transition from mostly older, less efficient buildings to newer, Amendment-compliant buildings. At the neighbourhood level this report considers the impacts of greater uptake of active transport and improved green infrastructure, among others.

To assess neighbourhood and entire study area impacts, SGS' analysis uses population and employment projections at the small area level for Victoria, and from that estimates the pace of new buildings being built in neighbourhoods. Under the base case, all new buildings are assumed to either be ESD compliant or non-ESD compliant, depending on the council area they are built in. Under the project case, all new buildings are expected to be Amendment compliant and thus generate less greenhouse gas emissions, save water etc; over time more and more Amendment compliant buildings are established, and non-Amendment compliant buildings gradually become a smaller share of the total built environment in Victoria.

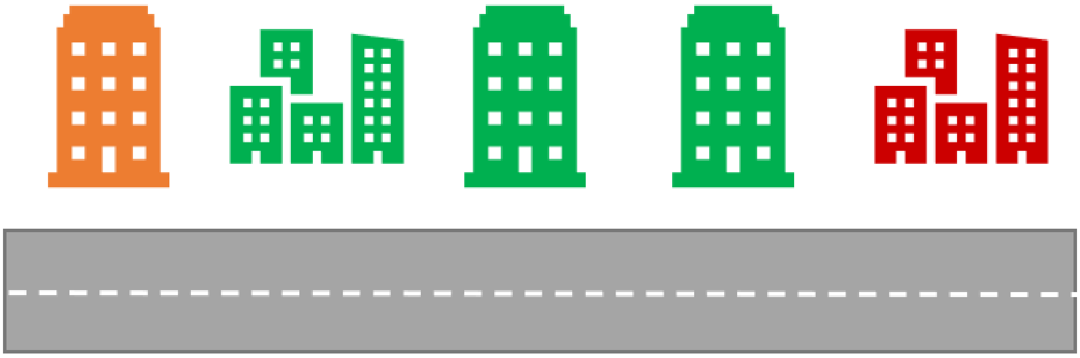
Base case scenario

Neighbourhoods across Victoria with a combination of ESD and non-ESD buildings



Project case scenario

Neighbourhoods across Victoria with a combination of ESD and non-ESD buildings, which are gradually replaced with Amendment buildings



This allows SGS to estimate **neighbourhood benefits**, a form of externality where a critical mass of Amendment standard buildings will result in benefits to people who live or work in the same neighbourhood, even if the buildings they live or work in are not Amendment-standard themselves.

In addition, SGS made several other updates to the analysis:

- Used an updated cost of carbon of $123-$150/tonne based on recently released NSW Guidelines for Cost Benefit Analysis, instead of $75/tonne;
- Quantified benefits that had not been quantified by Frontier;
- Updated the benefit parameters for energy, water and gas;
- Extended the timeframe for analysis to 40 years;

- Uprated construction costs (increased to account for inflation).

New benefits considered

SGS researched a number of benefit measures that had not been quantified by Frontier Economics, that SGS had modelled in previous projects, which are discussed in detail in Section 3. A summary of the benefits modelled by SGS, including new benefits, is shown in the table below.

Benefit	Monetised by Frontier	Monetised by SGS	Not possible to quantify	Too minor
GHG emission reduction from buildings	*	*		
Reduced energy use	*	Retail pricing		
Avoided health costs of electricity generation	*	*		
Reduced potable water use	*	Retail pricing		
Reduced embodied carbon	*	*		
Recovery of organic waste	*	*		
Residual value	*	*		
Increased active transport (esp cycling)		*		
Increased uptake of EVs		*		
Improved air quality in buildings				*
Carbon sequestration		*		
Improved health – neighbourhood effects		*		
Reduction in stormwater treatment costs		*		
Infrastructure savings – paths				
Increased biodiversity				

Findings of the cost benefit analysis

The impacts of the Amendment have been classified into six categories:

- **Operational energy**: This covers the reduction in electricity and gas used as a result of more energy efficient construction, avoidance of gas as an energy source and more energy efficient appliances. The benefits of operational energy include the reduction in electricity and gas costs and the reduction in associated greenhouse gas emissions. The costs include the higher costs of construction to achieve energy efficiency and the cost premium of energy efficient appliances.

- **Sustainable transport**: This covers provisioning new buildings to support use of electric vehicles (EVs), walking and cycling. The benefits include the neighbourhood benefits of higher uptake of electric vehicles and an increase in the share of people cycling to work in neighbourhoods with a higher share of Amendment buildings. The costs include the upfront costs of installing EV charging infrastructure, bike parking and end of trip facilities.
- **Integrated water management**: The reduction in potable water use and improved quality of stormwater discharging from providing water efficient fixtures and appliances, and for rainwater harvesting where suitable. The benefits are a reduction in potable water consumption and the value of recovered organic waste.
- **Indoor environmental quality**: Improvements in external shading, ventilation and sunlight access. While this is expected to have benefits it was not possible to quantify these except at a very minor level.
- **Circular economy**: The costs of implementing a program of resource recovery and using reusable materials, which are offset by the benefits of avoided landfill costs and externalities, and costs avoided in using recycled materials.
- **Green infrastructure**: This includes allowing for higher levels of canopy cover when new buildings are constructed, and includes costs such as reducing building footprints to allow for more trees, or sturdier roofs to allow for green roofs and gardens. The benefits include carbon sequestration, improved mental health and reduced water treatment costs.

The results of the CBA are shown in the table below.

COST BENEFIT ANALYSIS RESULTS ($ BILLION, 2023 DOLLARS)

Discount rate	7%		3%		10%	
	Costs	Benefits	Costs	Benefits	Costs	Benefits
Operational Energy	$1.32	$8.09	$1.49	$15.23	$1.42	$5.48
Sustainable Transport	$0.37	$0.73	$0.49	$1.36	$0.30	$0.51
Integrated Water Management	$0.11	$0.44	$0.35	$0.95	$0.06	$0.27
Indoor Environment Quality (IEQ)	$2.79	$-	$3.78	$-	$2.30	$-
Circular Economy	$0.94	$1.46	$1.28	$2.96	$0.77	$0.96
Green Infrastructure	$7.82	$9.05	$10.57	$15.81	$6.46	$6.27
Total impacts	$13.36	$19.78	$17.96	$36.30	$11.31	$13.49
Net present value	**$6.42**		**$18.34**		**$2.18**	

Benefit cost ratio	1.48		2.02		1.19	

The CBA shows that under the default 7% discount rate, the total net present value of applying the Amendment to 20 years' worth of construction amount to $6.42 billion dollars across Victoria; or a benefit cost ratio (BCR) of 1.48, which means that $1 spent on Amendment upgrades produces $1.48 worth of benefits. That is a robust BCR, especially given the fact that a number of benefits were not included to prevent any level of double counting.

Sensitivity testing

Sensitivity analysis involves testing the CBA with more conservative and more generous assumptions to allow for the possibility that some estimates of values may turn out to be too high or too low, and allows for a means of risk reduction.

SGS conducted a sensitivity analysis by changing the discount rate to 3% or 10%, and found that this impacts the results, but not substantially.

The main factor that the analysis is dependent on is the cost of carbon emissions. Reducing the cost of carbon to $75/tonne results in the BCR falling to 1.12, and removing the cost of carbon completely results in it falling to 0.58. A higher carbon price suggested by a recent analysis in Nature of $308/tonne produces a BCR of 2.8.

Financial case studies

SGS prepared a series of financial case studies to illustrate the direct financial impacts the proposed Amendment may have on specific stakeholders: developers, landlords, owner occupiers and tenants, all of whom would be financially affected by the higher upfront construction costs of the Amendment and the ongoing financial savings.

In general, the financial impacts on specific stakeholders in a balanced market (no excesses of supply or demand) are:

- Developers: Will experience some increase in financing costs and construction costs, which will be passed onto purchasers through higher prices.
- Landlords: Will pay a higher price for the property upfront, will charge higher rents to cover increased loan repayments. If the landlord is responsible for electricity, gas and water bills, they may experience savings in these expenses that will offset their increase in loan repayments.
- Owner occupiers: Will pay a higher price for the property upfront and face higher mortgage costs. In most cases, owner occupiers will not recover their higher costs through lower utility bills, however some may recover costs through the use of other building features such as fitouts for EV charging and taking up bike commuting.
- Tenants: Will pay higher rent, which in most cases is greater than their expected savings in utility costs. Some tenants may recover costs through use of other features such as bike facilities, EV charging and use of green spaces.

Caveats to the costings

The nature of the calculation of benefits in this project, in particular, the use of specific buildings as hypothetical examples representing the breadth of Victorian building development, may result in the costs of some of the amendments being overstated and some of the benefits being understated. Two key examples are:

- Estimation of benefits for the Amendment considered the energy savings from building design, but the additional benefits of shading, ventilation and green infrastructure on the resident's power bills were not quantified to avoid double counting with other building design standards. As a result, impacts on comfort, health and power bills may be underestimated.
- Estimation of the costs of green infrastructure for all projects were based on a landscape architect developing the green infrastructure. While this level of expertise will be necessary for medium to high density developments, it may not be necessary for some lower density developments. The cost of the Amendment to lower density dwellings could be substantially reduced from the estimates used in these calculations if the green space was created by a landscape designer, gardener or even the property owner.

Conclusion

This analysis shows that overall, the proposed impact of the Amendment is expected to be positive, and the results are robust to sensitivity testing. The main sensitivities of this analysis are the cost of carbon (without this, the benefits do not cover the costs) and the relative prices of gas, standard electricity and green electricity. It should be noted that the purpose of the Amendment is to support Councils moving to net zero, and it fulfils this purpose.

When considering potential distributional impacts, the costs of the Amendment are borne by the end users of the buildings, but the benefits are diffuse, affecting neighbourhoods and even the entire world through the reduction in carbon emissions. This means that some disadvantaged households or small businesses may find the costs to their personal finances of the Amendment may be greater than the benefits they personally experience. However, the actual returns to developers, landlords, owner occupiers and tenants is heavily dependent on what the market will bear at the time, rather than the cost of the initial build of the dwelling, suggesting this Amendment is unlikely to be the pivotal factor in determining the costs of the purchasing or price of rent. Nonetheless, these disadvantaged households should be considered for additional support to ensure that they are not left worse off.

1. Introduction

Residential buildings are responsible for one quarter of Australia's greenhouse gas emissions (Martek & Hosseimi, 2019), from the carbon emissions generated in the construction and from the energy consumption while using the buildings.

Commercial and industrial buildings also have a significant impact, although the emissions from the building are difficult to separate from the industrial processes going on inside them.

Federal, state and local government bodies in Australia all have a role to play in ensuring that Australia reduces its carbon emissions through ensuring that commercial, residential and industrial buildings are built in a manner that not only minimises carbon emissions in construction, but also reduces carbon emissions when established, through:

- Ensuring sufficient insulation and ventilation to keep buildings cool in summer and warm in winter without excessive reliance on artificial climate control;
- Ensuring that appliances put in place with buildings are energy efficient, particularly those relating to heating and cooling;
- Where possible, provide for renewable energy generation and battery storage on-site or off-site (e.g. solar panels; note that high rise apartment buildings may not have sufficient roof space to cover their own energy efficiency needs);
- Establish buildings that support residents and users in switching away from internal combustion engine vehicles for transport;
- Design buildings that can support trees, shrubs and green space to regulate temperatures inside and outside of buildings, reduce stormwater runoff costs, improve wellbeing of building users and absorb carbon.

This analysis reviews the proposed Sustainability Planning Amendment which aims to ensure that new buildings are as close to carbon neutral as possible.

1.1 Background to this analysis

The Council Alliance for a Sustainable Built Environment ("CASBE") is an alliance of Victorian councils committed to the creation of a sustainable built environment within and beyond their municipalities. It aims to improve sustainability outcomes in the built environment using the planning permit application process, and supports councils engaging with developers in developing more energy efficient buildings.

The Municipal Association of Victoria ("the MAV") is the peak body for local government in Victoria. The MAV is an influential force supporting a strong and strategically positioned local government sector. The MAV's role is to represent and advocate the interests of local government, raise the sector's profile, ensure its long-term security and provide policy advice, strategic advice, capacity building programs and insurance services to local government. CASBE is auspiced by the MAV.

Councils from across Victoria have joined forces to push for more sustainable design within planning requirements. On 21 July 2022, 24 councils lodged a Planning Scheme Amendment (referred to as "the Amendment" in this report) with the State Government, seeking to introduce planning provision that elevates sustainability requirements for new buildings and encourages a move towards net zero carbon development.

MAV, on behalf of CASBE, has sought expert advice to enable the development of a Planning Scheme Amendment, with a range of new elevated standards of sustainability in buildings. The purpose of the elevated standards is to ensure that new buildings and significant alterations and additions are planned and designed in a manner which mitigates and adapts to climate change, protects the natural environment, reduces resource consumption and supports the health and wellbeing of future occupants.

1.2 Purpose of this CBA

SGS Economics and Planning ("SGS") was commissioned by CASBE to prepare a CBA of the proposed Planning Scheme Amendment ("the Amendment"). The aim of the CBA is to assess if the Amendment is likely to generate net welfare gains for Victorians, taking into consideration all economic, social, and environmental costs and benefits from a community welfare perspective. While the CBA's key performance measures (e.g., Net Present Value, Benefit Cost Ratio) focus on the monetised costs and benefits experienced by Victorians, it also:

- Incorporates costs and benefits that are difficult to quantify/monetise,
- Explores the welfare gains generated by the Amendment outlined on an individual and collective basis, and
- Identifies how costs and benefits are experienced by current and future residents of the CASBE Councils, surrounding community members and Victorians more broadly.

Distinguished from Frontier Economics' CBA, this CBA:

1. Considers context changes since the previous analysis was completed.

Since March 2022, there have been several key changes in State and Federal governments and in policy, along with changes to costs of ultilities and construction, that could affect the assumptions used for the base case for the cost-benefit analysis. These changes cover a number of matters relevant to this project, including energy efficiency, renewable energy and EVs, which are likely to impact benefits across numerous categories, such as Operational Energy, Sustainable Transport and Green Infrastructure.

2. Considers benefits that accrue at a neighbourhood level.

The previous work undertaken addressed the benefits/cost on an individual building basis. As such, several benefits were difficult to rationalise in the modelling as they were more likely to occur across small areas, such as neighbourhoods/precincts. SGS has approached several benefits of the evaluation from green infrastructure at a neighbourhood level; for example:

- Public bike parking on the street front of a new development will support bike travel to that development and neighbouring buildings;
- Street facing trees and green areas in private buildings, or any trees and green areas in public buildings, will have benefits to the wider neighbourhood who may experience a more comfortable temperature, improved mental health and greater inclination to active travel.

Otherwise, SGS' method builds on from Frontier's approach and, where possible, maintains consistency.

1.3 Report structure

The report is structured in 6 sections following this introduction:

- Section 2 briefly summarises the method and evidence base used in the Frontier Economics report, and describes how SGS' approach differs from this.
- Section 3 describes how the costs and benefits in addition to those used by Frontier were calculated.
- Section 4 describes the results of the cost benefit analysis.
- Section 5 describes the results of a series of financial case studies.
- Section 6 concludes.

2. How this analysis differs from its predecessor

In March 2022, Frontier Economics presented a cost benefit analysis (Frontier Economics, 2022) for the Sustainability Planning Scheme Amendment to the MAV on behalf of CASBE.

The case for higher sustainability standards for buildings in Victoria was based on three arguments:

- Information asymmetry - it is difficult to detect energy efficiency and thermal comfort in a new or existing building; when buyers do not have perfect information, it leads to inefficient outcomes;
- Negative externalities – energy prices that do not reflect the total costs of energy, including environmental costs such as the cost of carbon emissions and urban heat island effects, and;
- Principal-agent problems – the purchaser/renter of a new property faces different objectives of those constructing the new buildings – the former may want to save energy costs and increase their comfort in the long run, while the builders may want to save costs wherever possible.

Frontier's report for CASBE was produced in March 2022, which focused on the first phase of the 'Elevating ESD targets' project. Their approach assessed the costs and benefits tied to the elevated standards for new buildings if ESD policy became standardised for all Victorian Councils. The analysis accounts solely for the effects on the 31 CASBE Councils.

2.1 Details of the Frontier Economics analysis

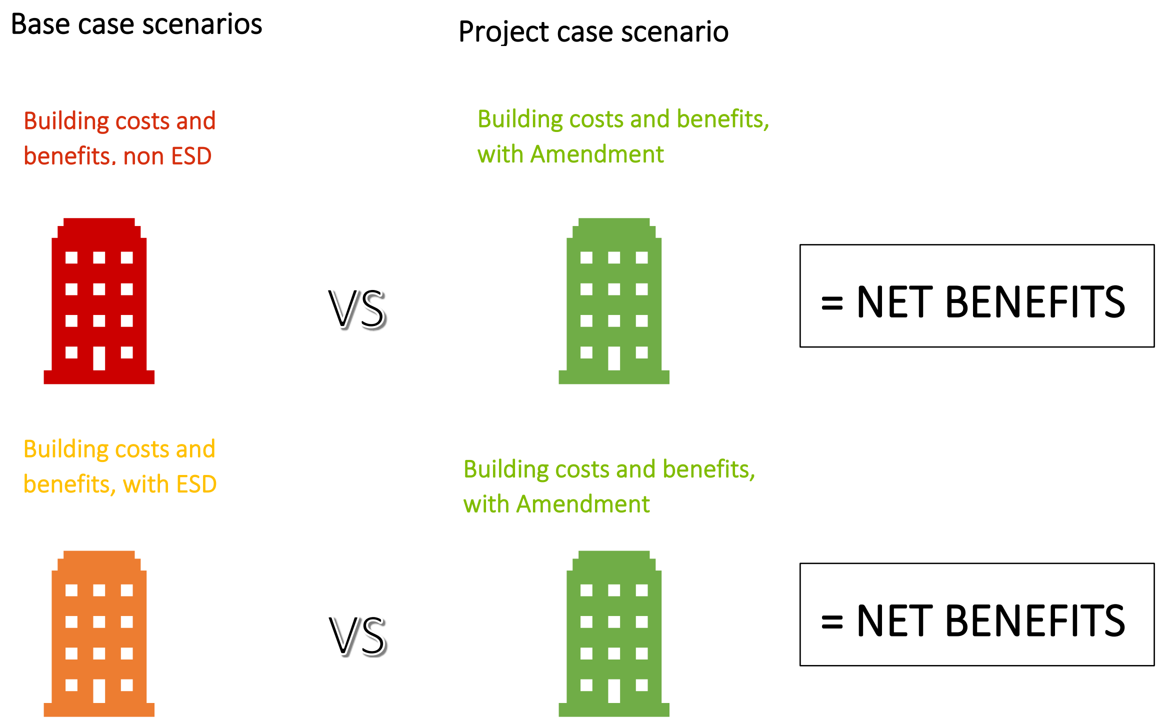
Base case and project case

Frontier Economics used two alternative base cases: One for councils which did not have an existing ESD policy in place, and one for councils which did have an existing ESD policy.

The project case scenario is one in which the Sustainability Planning Scheme Amendment is implemented.

The analysis compared the project case scenario against each base case scenario, producing two sets of results, as shown below.

FIGURE 1 BASE CASE FOR FRONTIER ANALYSIS



Building typologies

The impacts of the project case compared to the base cases were estimated by calculating the total construction costs, energy usage, water usage and so forth of a set of specific building types under a regime with no ESD policy in place, one with ESD policy in place and one with the Sustainability Planning Scheme Amendment in place.

The set of specific building types, or building typologies, each had a different structure of costs and benefits. The building typologies are shown in Table 1.

TABLE 1: BUILDING TYPOLOGIES USED IN FRONTIER ANALYSIS

Typology	Inner Urban	Suburban	Regional
RES 1 - Large residential mixed-use development >50 apartments and small retail	ESD Policy	Non-ESD Policy	
NON_RES 1 - Large non-residential > 2,000 m2 GFA office development	ESD Policy	Non-ESD Policy	
RES 2 - Small multi-dwelling residential <3 dwellings		ESD Policy	Non-ESD Policy

NON-RES 2 - Large industrial >2,000 m2		ESD Policy	Non-ESD Policy
RES 3 - Small multi-dwelling residential >5 dwellings but <10 dwellings	ESD Policy	Non-ESD Policy	
NON-RES 3 - Small non-residential office and retail <2,000 m2	ESD Policy		Non-ESD Policy
RES 4 - Small residential apartment building >10 dwellings by <50 dwellings		ESD Policy Non-ESD Policy	
RES 5 - Single dwelling and/or residential extensions greater than 50 m2		Non – ESD Policy	

Source: Frontier Economics (2022)

For each of these building typologies, Hip v Hype (2022) generated a detailed set of costings under the base case and under the project case, in which the Amendment was implemented. The costings took into account detailed construction costs and ongoing operational costs. Frontier used these as a basis of calculating its benefits.

Findings

The analysis found that the Amendment's changes did not result in a positive NPV for any building typology under either of the base cases. However, it found that if the costs of indoor environment quality (IEQ) and green infrastructure (GI) were excluded, then all of the building typologies produced a positive NPV under at least one of the base cases.

2.2 Changes to the base case

Updating for changes in political context

Since March 2022, there have been several key changes in State and Federal governments and in policy, that could affect the assumptions used for the base case for the cost-benefit analysis. These changes are centred around renewable energy, which is likely to impact benefits across numerous categories, such as Operational Energy, Sustainable Transport and Green Infrastructure.

- The National Construction Code 2022

In 2022, the Australian Building Codes Board released a new version of the National Construction Code, with the new requirements to be adopted from 1 May 2023. Some of these changes have some overlap with the provisions of the Amendment. These include:

  - Increasing the Nationwide House Energy Rating Scheme (NatHERS) standards for residential buildings to a minimum of seven stars. This includes a new whole-of-home annual energy budget (which applies to heating and cooling equipment, hot water systems, lighting and swimming pool and spa pumps)

- Commercial buildings require some commercial buildings to have features to support future installation of onsite renewables and electric vehicle charging.
- Increasing requirements for drinking water efficiency

Along with other changes relating to access/egress, layout for improving access for people with mobility difficulties, waterproofing, soundproofing, condensation management and other structural matters.

- **Changes to State Context**

A new State government was formed following the 2022 November elections, with the Labor Government re-elected. Former DEWLP's portfolios were spilt across two re-established departments - the Department of Energy, Environment and Climate Action, and the Department of Transport and Planning. This signals a new trajectory and more urgent prioritising of policies/programs centred around environmental sustainability.

The Victorian Government has made election commitments to set up a state-owned energy company for new wind and solar projects. This is anticipated to build 4.5 gigawatts of energy generation. Concurrently, the State will invest a billion dollars in renewable energy projects. These investments will keep electricity prices down compared to natural gas prices.

The State has also fast-tracked coal exit with advanced closures of the Loy Yang A plant. The state-owned energy investment and an advanced pathway out of brown coal have accelerated the pipeline, leading to renewable targets being lifted. If Victoria achieves these targets, it will see interim emissions reduction targets of 65% by 2030, up by 15%, and emissions reduction of 65% by 2030, up by 15%. The State roadmap includes reaching 95% of renewables by 2035.

At the start of this year, there has also been a change in policy that has banned compulsory embedded networks from new apartments. This change will enable residents to make independent choices as to what type of energy they want to purchase.

There were no commitments tied to changing policies and targets with electric vehicles. Rather, the Victorian Government will continue the Zero Emission Roadmap with aims for half all light vehicle sales in Victoria to be zero-emissions vehicles by 2030.

- **Changes to Federal Context**

The broader Australian political environment has also changed since Frontier's report was released. In May 2022, the federal election was held, with a new Labor government elected. A core vision for the Labor government was to turn Australia into a "renewable energy superpower" and "end the climate wars". This marked a significant opportunity in the nation's transition.

Since then there have been numerous changes to policy and targets, including:

- A newly established department aimed at responding to climate change and sustainable energy, and protecting Australia's environment, DECCEEW.
- The nationally determined emissions reduction targets, previously set as part of the Paris Agreements, were lifted in June 2022. The targets now commit Australia to 43% below 2005 levels in 2030, and net zero emissions achieved by 2050.
- The Climate Change Act 2022 was passed by the Australian Parliament and Senate in September 2022. This Act has tied Australia's targets with legislation.
- The government has planned to invest $20b to rebuild and modernise the nation's electricity network through the Rewiring the Nation plan. This will see the share of renewables grow by 82% in the National Electricity Market by 2030. Investment into this project will seek to maximise the benefits of rooftop solar and deliver solar banks for households unable to access rooftop solar. Concurrent, the National Reconstruction Fund will help build Australia's industrial capabilities, with funds directed to clean energy manufacturing support.

Carbon intensity

SGS considered updating the Frontier analysis to take into account the changes in these impacts. The key Frontier assumption was based on the expected decline in carbon intensity of Victoria's electricity generation network over time, expressed in tonnes of carbon dioxide equivalent emissions per megawatt hour, as coal fired power is phased out and new renewable electricity generation comes online. However, Victorian projections of carbon intensity have not been updated since the Frontier analysis was completed, with plans for a review in 2023, according to timelines published by Engage Victoria (2021).

Impact of NCC 2022

SGS has also compared the new requirements of NCC 2022 to the requirements under the Amendment. Generally the Amendment goes further than the NCC 2022; while both require residential developments to have an average 7 star NatHERS rating, the Amendment also proposes additional energy saving/GHG reduction requirements, including all-electric building design in most circumstances, optimising for solar energy and onsite renewable energy where possible. The Amendment also goes further in allowing for EV provision and bike facilities.

The previous analysis noted that the NCC 2022 would require a 7 star NatHERS rating, and that the analysis would need to be updated if this was to eventuate.

In the previous analysis, the impact of these changes compared to the base case were quantified by Hip v Hype. As SGS does not have the expertise to quantify how differences between the original project base cases, updates to the NCC 2022 are not included in the previous analysis and the proposed Amendment.

In addition, while it is likely that supportive government policy will result in a faster uptake of electric vehicles, no official recent projections have been made, and in any case, Frontier did not estimate the value of additional electric vehicle takeup.

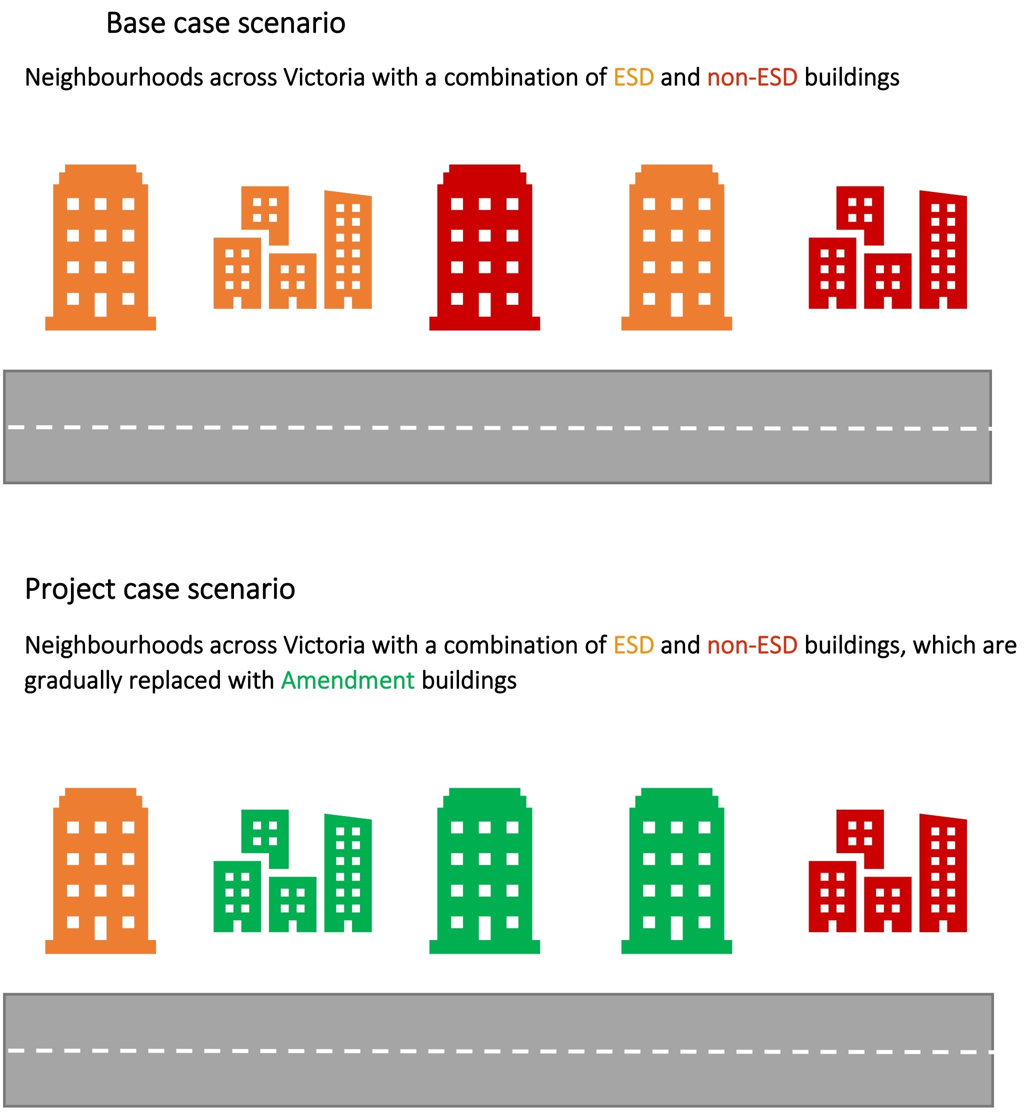
SGS' base case

Instead of considering a series of hypothetical buildings under non-ESD, ESD or Amendment regulations, SGS considered the overall impact on Victoria of ESD and non-ESD policy councils adopting the Amendment, across the entire study area.

Using small area population growth and jobs growth driving demand for new buildings, as well as some level of substantial renovation and rebuilding, estimates were made of the annual new building at the neighbourhood level.

Under the base case, as shown in Figure 2, all new buildings are assumed to either be ESD compliant or non-ESD compliant, depending on the council area they are built in. Under the project case, all buildings are expected to be Amendment compliant; over time more and more Amendment compliant buildings are established, and non-Amendment compliant buildings gradually become a smaller share of the total built environment in Victoria.

FIGURE 2: SGS BASE CASE AND PROJECT CASE SCENARIO



2.3 Changes in allocation of building typologies

To scale the existing outcomes modelled by Frontier to a neighbourhood level, Hip v Hype's building typology case studies and cost inputs have been used in our calculation of new buildings and/or significant redevelopment costs.

Firstly, a density classification was also applied based on Frontier's concordance using the overarching zoning of each neighbourhood. SGS then used a simple method of assigning each neighbourhood a building typology that is typically prevalent in the area, with the use of several Hip v Hype typologies and case studies. Note that these case studies do not provide a full picture of the range of residential building types that may exist, however do provide a decent variety which allows us to estimate the costs and benefits that accrue to households in different density neighbourhoods. The residential typologies have been summarised in the table below.

TABLE 2: SUMMARY OF RESIDENTIAL TYPOLOGIES

Typology (Hip v Hype)	No. of dwellings per building	SGS assigned density
CS1 RES 1 - Large residential mixed-use development >50 apartments and small retail	217	High Mixed
CS2 RES 1 - Large residential mixed-use development >50 apartments and small retail	142	High Mixed
CS7 RES 2 - Small multi-dwelling residential <3 dwellings	3	Low
CS8 RES 2 - Small multi-dwelling residential <3 dwellings	2	Low
CS9 RES 3 – Small multi-dwelling residential >5 dwellings but <10 dwellings	5	-
CS10 RES 3 – Small multi-dwelling residential >5 dwellings but <10 dwellings	6	-
CS11 RES 4 - Small residential apartment building >10 dwellings but <50 dwellings	12	Med
CS12 RES 4 - Small residential apartment building >10 dwellings but <50 dwellings	16	Med
CS15 RES 5 - Single dwelling and/or residential extensions greater than 50 m2	1	-

Source: Hip v Hype, 2021

Throughout our analysis, we have taken an average dwellings to building ratio. Additionally, we have assumed that new residential buildings established in high-density, mixed-use zones will take on largely a ‘RES 1’ typology; new buildings in medium-density zones will be commonly RES 4 and new buildings in low density areas as typically attributes of RES 2.

TABLE 3: BUILDING TYPOLOGIES USED - RESIDENTIAL

ESD status of Council	Zone	Typology – Residential	Average dwellings per building
ESD	High Mixed	RES 1 – Inner Urban ESD Policy	179.5

non-ESD	High Mixed	RES 1 – Suburban Non-ESD Policy	179.5
ESD	Med	RES 4 – Suburban ESD Policy	14.0
non-ESD	Med	RES 4 – Suburban Non-ESD Policy	14.0
ESD	Low	RES 2 – Suburban ESD Policy	2.5
non-ESD	Low	RES 2 – Regional Non-ESD Policy	2.5

Source: SGS Economics and Planning, 2023

The non-residential typologies from Hip v Hype have been summarised in the table below.

TABLE 4: SUMMARY OF NON-RESIDENTIAL TYPOLOGIES

Typology (Hip v Hype)	Region
CS3 NON-RES 1 - Large non-residential >2,000 m2 GFA office development	Inner Urban
CS4 NON-RES 1 - Large non-residential >2,000 m2 GFA office development	Suburban
CS5 NON-RES 2 - Large industrial >2,000 m2	Suburban
CS6 NON-RES 2 - Large industrial >2,000 m2	Regional
CS13 NON-RES 3 - Small non-residential office and retail <2,000 m2	Inner Urban
CS14 NON-RES 3 - Small non-residential office and retail <2,000 m2	Regional

Source: Hip v Hype, 2021

Table 5 shows SGS' allocation of non-residential building typologies by location and zoning. For example, for regional high mixed neighbourhoods, non-residential buildings may typically take on similar features to a large non-residential >2,000 m2 GFA office development. And as such, take on the same costs.

While the region may differ compared to where it has been previously estimated, the cost variation will be more immaterial than GFA differences. This approach has been taken due to limited data availability, however, costs have been tested in the sensitivity.

TABLE 5: BUILDING TYPOLOGIES USED - NON-RESIDENTIAL

Location	Zone	Typology – Non residential
Regional	High Mixed	NON-RES 1 – Suburban
Suburban	High Mixed	NON-RES 1 – Suburban

Inner Urban	High Mixed	NON-RES 1 – Inner Urban
Regional	Med	NON-RES 3 – Regional
Suburban	Med	NON-RES 1 – Suburban
Inner Urban	Med	NON-RES 1 – Inner Urban
Regional	Low	NON-RES 3 – Regional
Suburban	Low	NON-RES 1 – Suburban
Inner Urban	Low	NON-RES 3 – Inner Urban
Regional	NA	NON-RES 3 – Regional
Suburban	NA	NON-RES 1 – Suburban
Inner Urban	NA	NON-RES 3 – Inner Urban

Source: SGS Economics and Planning, 2023

Building typologies excluded

Note that not all of the building typologies in the Frontier and Hip v Hype analysis have been included in the SGS analysis.

RES 3

For residential neighbourhoods, RES 3 (small multi-dwelling residential dwellings) were not used. RES2, RES4 and RES1 were used as the key representative residential dwelling types as RES3 is expected to have impacts that are midway between those of RES2 and RES3. It was not possible to estimate within the project parameters how many new buildings would be RES2, RES3 and RES4, so medium to low density multi-unit dwellings were estimated as RES2 and RES4.

RES 5 – Single dwellings

RES 5 (single dwellings) were not used. As the Amendment excludes single-detached properties, the low and medium-density neighbourhoods take on larger building allocations than what is seen across the neighbourhood. We expect low-density areas to be only affected by the proposed Amendment changes where buildings are typically townhouses or units. Medium-density regions also consider the single detached properties, as such, we would expect mostly multi-level apartment buildings on average.

NON-RES 2 – Large industrial buildings

For non-residential neighbourhoods, NON-RES 2 (large industrial buildings) were excluded from the analysis. This was partly to simplify the allocation of non-residential building typologies across the state, and partly as many of the proposed changes in the Amendment will have minimal or negligible impact on the standards for these buildings. Industrial buildings may well house businesses expected to have high water use or high energy use in the future, so it makes economic sense for these businesses to install solar panels or water tanks in any case, regardless of the Amendment. The type of work done in industrial areas means that workers in these areas are less likely to ride to work as they may have to bring tools or visit several sites in one day, creating less demand for cycling infrastructure than one might expect in an office environment. Additionally, workers with a manual job that gives them plenty of exercise may not receive additional health benefits from taking up cycling.

Finally, the most significant cost of the Non-Res 2 cost estimates is green infrastructure, and in most cases developers will be able to easily adapt an industrial building design to substantially reduce the costs of meeting green infrastructure requirements, so the estimates provided by Hip v Hype are likely to be an overestimate of green infrastructure costs.

Without further information on building types within each neighbourhood, it was not possible to estimate a further breakdown of the building typologies that may be found, hence only one typology type was applied per neighbourhood.

2.4 Changes in benefit parameters

In most cases, SGS based the benefits analysis on the Frontier method to maintain consistency. A summary of Frontier Economics' methodology can be found in the Appendix 2 of this report.

However, this CBA made changes to the way the impacts of the project case have been calculated. These are summarised in Table 6 and explained in more detail below.

TABLE 6: CHANGES TO PARAMETERS SINCE FRONTIER REPORT

Benefit	Differences in method
GHG emission reduction from buildings	Updated cost of carbon ($123-150 v $75/tonne)
Reduced energy use	Retail electricity prices instead of wholesale, based on the retail energy prices in Victoria in January 2023 (St Vincent de Paul Society, 2023)
Reduced potable water use	2023 water costs used, using retail costs instead of wholesale costs
Reduced embodied carbon	Updated cost of carbon, as above

Source: SGS Economics and Planning (2023)

Cost of carbon

The Frontier analysis used a cost of carbon emissions of $75. SGS has considered research published since the report was released, suggesting that $75/tonne is too low. SGS has considered two possible sources: Market prices for carbon based on NSW Treasury parameters, and the social cost of carbon calculated in a recent article in Nature.

NSW Treasury, market prices

The recently released NSW Government Guide to Cost Benefit Analysis from the NSW Treasury (2023) has developed a series of parameters for valuing carbon emission reduction, based on the spot prices for the European Union's Emissions Trading Scheme (ETS) (NSW Treasury, 2023) and converted to Australian dollars based on the 2022 exchange rate, and increased by 2.25% per annum beyond FY 2023. The cost of carbon is estimated at $123 in the 2023 financial year and increases to $150 by FY2032.

Nature, social cost of carbon

Research published in *Nature* since the Frontier analysis was released suggested that existing estimates of the cost of carbon were too low, and suggested a social cost of carbon of US$185 per tonne in 2020 dollars (*Comprehensive evidence implies a higher social cost of CO2* (Rennert, et al., 2022). This translates to 2023 AUD$308/tonne.

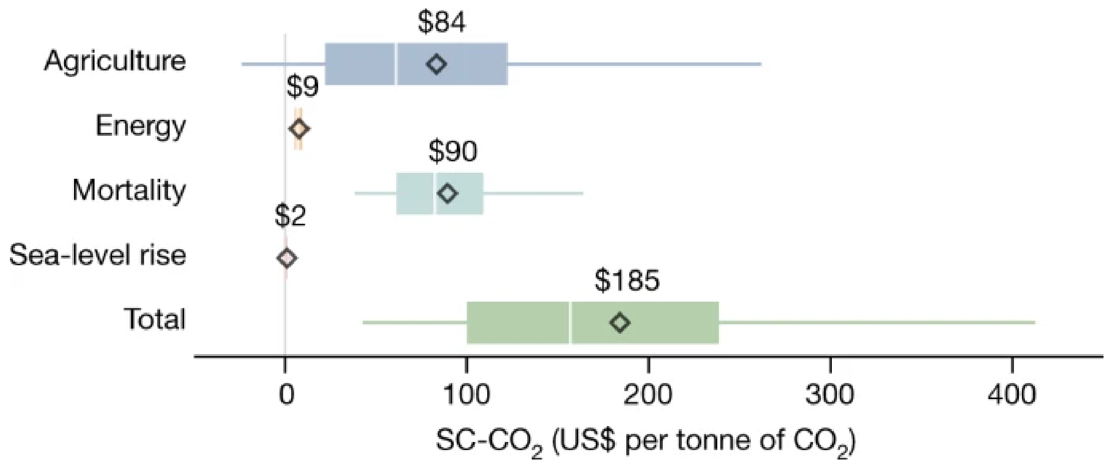
The analysis in the *Nature* report notes that the leading integrated assessment models (IAMs) which use a four-step process to quantify a present value of economic damage from a unit of carbon have not kept pace with advances in climate, economic and demographic science. These IAMs now use outdated climate models that show temperature dynamics inconsistent with more sophisticated Earth system models, and are based on studies of damage from several decades ago.

The new method uses a probabilistic method of analysis to take account of uncertainties around projections of population, GDP per capita, global emissions and future changes in technology. It uses a 2% near term risk free discount which is "related to stochastic consumption growth in a Ramsey-like equation, which is the commonly used approach to value marginal impacts amid uncertainty in future payoffs and consumption level" (Rennert, et al., 2022). This means that the parameterisation of the discount rate captures risk preferences by allowing for uncertain consumption growth, by assuming consumption growth follows a random probability distribution.

The breakdown of the incidence of costs of carbon is shown in Figure 3 below.

FIGURE 3: COMPONENTS OF DAMAGE FROM CARBON EMISSIONS

Fig. 3: Partial SC-CO_2 estimates and uncertainty levels strongly differ across the four climate damage sectors.



Box and whisker plots for the climate damage sectors included in the GIVE model, based on partial SC-CO_2 estimates for each sector. The figure depicts the median (centre white line), 25%–75% quantile range (box width), and 5%–95% quantile range (coloured horizontal lines) partial SC-CO_2 values. Black diamonds highlight each sector's mean partial SC-CO_2, with the numeric value written directly above. All SC-CO_2 values are expressed in 2020 US dollars per metric tonne of CO_2.

Source: (Rennert, et al., 2022)
Note: SC-C02 = Social Cost of carbon dioxide (emissions); GIVE = Greenhouse Gas Impact Value Estimator, a new integrated assessment model for quantifying the benefits of reducing emission.

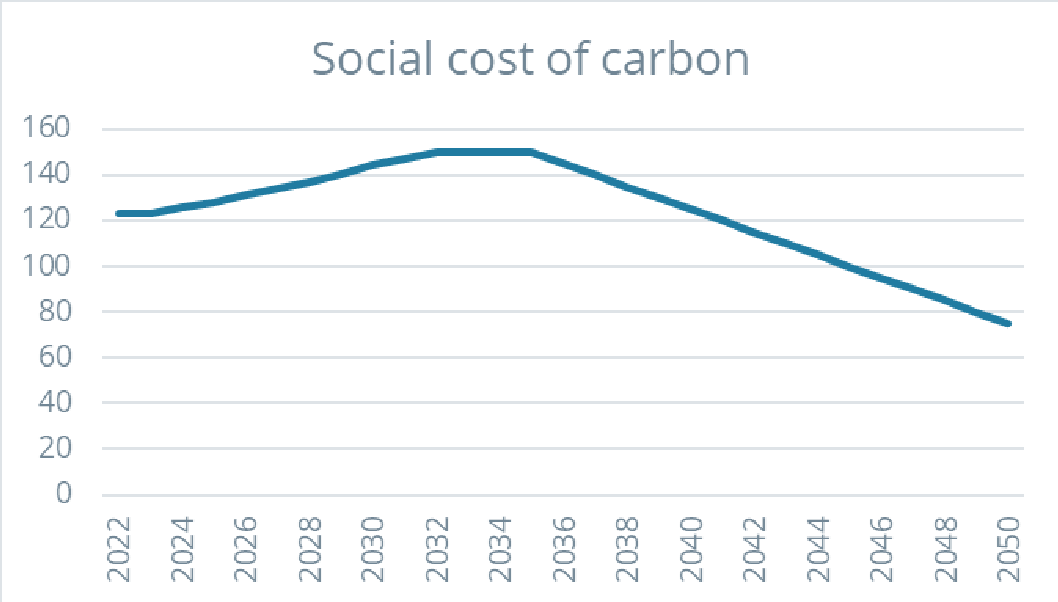
The main components of the social cost of carbon are future net negative impacts on agriculture, as changes to local climates impact the areas in which different types of food can be grown and more extreme weather conditions result in greater agricultural losses; and increases in mortality from extreme weather and and lack of food.

SGS estimates of cost of carbon

SGS has chosen to use the parameters set out in the NSW Treasury Guidelines in this analysis, as these are official parameters, recently estimated by an Australian government. The Nature parameter of $308 per tonne will be used in a sensitivity analysis.

It is likely that the marginal cost of an additional tonne of carbon in the atmosphere will decline over time as carbon reduction measures are more widely implemented and become more cost-effective. The cost of carbon has been estimated using the NSW Treasury parameters until 2035, after which it gradually declines to $75 over time to 2050, when Australia is expected to achieve net zero carbon emissions. After this date, the benefits of carbon emissions reduction are assumed to be zero.

FIGURE 4: SOCIAL COST OF CARBON



Source: SGS Economics and Planning calculations based on (NSW Treasury, 2023) and (Frontier Economics, 2022)

Electricity and gas costs

The Frontier analysis used the wholesale cost of electricity as its metric for the benefits of reductions in electricity use. SGS has used the retail cost of electricity as our metric in the analysis. Drawing from data gathered on retail energy prices in Victoria in January 2023 (St Vincent de Paul Society, 2023), SGS estimated a cost per kWh of electricity at 22.992 cents, and gas costs of 4.23c/Mj.

Data on the premium for carbon neutral power was drawn from major electricity supplier websites. A review showed that some suppliers who offer carbon neutral power do so at a rate of $1 or $1.50 per week, others offer at no additional cost, and are not apparently more expensive in total than the market average. To be conservative a premium of 1.3c/kWh was estimated carbon neutral power.

Water use

SGS used the average cost of water for Victorian households to estimate the benefits of water saving from more efficient buildings, at $3.32/KL in 2020-21 (ABS, 2022). This is more than the wholesale cost of water of $267 (Melbourne Water, 2023) used in the Frontier analysis.

SGS has decided to use retail prices for utilities rather than wholesale prices to ensure that the full benefits of saving on energy and water use are taken into account. While wholesale prices may be more appropriate for, say, electricity generation or transmission businesses making decisions on investments in cost reductions, this is less applicable when the main impacts of the project are targeted at end users of utilities, rather than utility companies themselves. Key stakeholders in this project; namely developers, landlords, owner-occupiers and tenants are all end users of retail electricity, gas and water, not providers or users of wholesale electricity, gas and water, so retail prices are more appropriate.

2.5 New benefits estimated

Frontier Economics considered the impacts of building specific benefits, including savings on energy use, reduction in potable water use in buildings and greenhouse gas emissions reduction from reduced energy use within the building and more efficient construction methods.

In addition to this, SGS also estimates impacts of carbon sequestration, health benefits from green infrastructure and reduction in stormwater costs.

SGS has also included neighbourhood benefits, in which the existence of a certain critical mass of buildings with certain features will benefit all users in the neighbourhood, even those living or working in older or non-compliant buildings.

TABLE 7: ADDITIONAL BENEFITS IN SGS CBA

Benefit	Monetised by Frontier	Monetised by SGS	Neighbourhood benefits
Operational energy			
GHG emission reduction from buildings	*	*	
Reduced energy use	*	*	
Avoided health costs of electricity generation	*	*	
Sustainable transport			
Increased active transport (esp cycling)		*	*
Increased uptake of EVs		*	*
Integrated water management			
Reduced potable water use	*	*	
Recovery of organic waste	*	*	
Indoor environment quality – benefits not quantified			
Circular economy			
Avoided costs of landfill and value of recycled materials recovered	*	*	
Green infrastructure			
Carbon sequestration		*	

Improved health – neighbourhood effects		*	*
Reduction in stormwater treatment costs		*	
Other			
Reduced embodied carbon	*	*	
Residual value	*	*	

Source: SGS Economics and Planning (2023)

The benefits considered in the Frontier analysis are the benefits generated by the building itself – for example, the savings in energy and water costs from a more energy efficient and water efficient building design.

SGS has added in additional building specific benefits related to the requirements for minimal levels of green cover – the benefits from green cover absorbing carbon and reducing stormwater runoff. These benefits begin accumulating as soon as a building is completed.

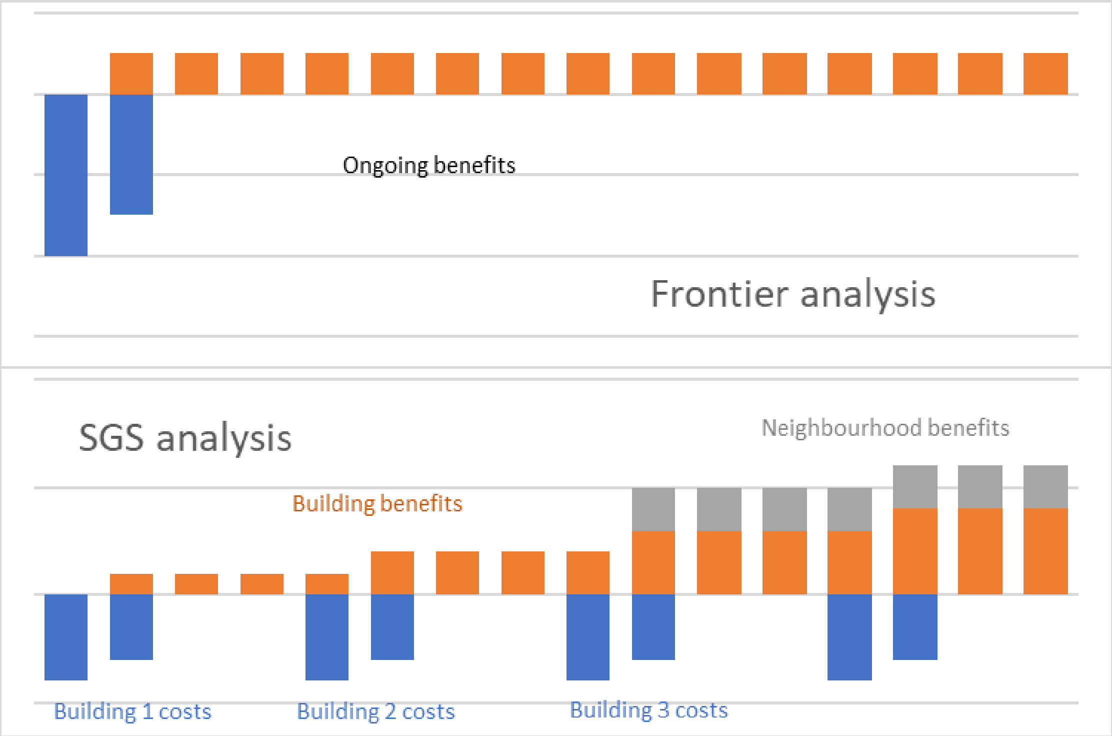
2.6 The use of neighbourhood benefits

Neighbourhood benefits accrue to users of a neighbourhood or precinct, not just people who use a building that is Amendment compliant. For example:

- Public bike parking on the street front of a new development will support bike travel to that development and neighbouring buildings;
- Street facing trees and green areas in private buildings, or any trees and green areas in public buildings, will have benefits to the wider neighbourhood who may experience a more comfortable temperature, improved mental health and greater inclination to active travel.

When the first buildings are constructed under the new standards, no neighbourhood benefits are expected to occur. However, once there is a certain 'critical mass' of new buildings that comply with the standards, users of non-compliant buildings in the neighbourhood will reap certain benefits. For example, EV users visiting non-compliant buildings will benefit from publicly available EV charging spots in compliant buildings, or at least less competition from street EV charging spots. Figure 5 provides an illustration of how these neighbourhood benefits are realised as a cumulation of building benefits. The blue bars illustrate the construction costs for a new or re-developed building, and the orange illustrates the benefits realised by building users throughout each building's useful life. In the SGS analysis, there is an additional layer of neighbourhood benefits shown in grey which are introduced once there is a certain critical mass of new buildings, in this illustration the critical mass is three new ESD-compliant buildings.

FIGURE 5 NEIGHBOURHOOD BENEFITS IN SGS ANALYSIS



How we calculated neighbourhood benefits

SGS drew on in-house small area projections of jobs by industry, population and dwelling numbers in Victoria to project the construction of new residential and commercial buildings over time.

As job numbers in a neighbourhood increased over time by a certain amount, a new commercial building is assumed to be built in that neighbourhood, which is compliant with the Amendment under the project case; and will be ESD-compliant or non-ESD compliant based on whether its local council has an ESD policy in place in the base case.

When dwelling numbers in a neighbourhood have increased by a certain amount, a new residential development is assumed to be built in that neighbourhood.

In addition to this, commercial buildings and residential apartments/townhouses are assumed to be either rebuilt or substantially renovated to the highest current standard every 40 years, which allows for a turnover of existing stock of 2.5% per year.

SGS then assumes that once 30% of buildings in a neighbourhood are ESD-compliant, certain neighbourhood benefits may be realised. This has not been based on any underlying data or research, but a qualitative sense that once three in ten buildings in a neighbourhood have certain facilities, then almost all people who do not live or work in an Amendment building will have several Amendment buildings within a short walk away.

3. Costs and benefits

This section identifies the incremental costs and benefits generated by the project case, along with the valuation techniques utilised.

The costs and benefits of the Amendment are listed in the table below (Table 8). On the cost side, most of the costs relate to the upfront costs of construction.

On the benefits side, there are a range of benefits that are either at the individual building level or the neighbourhood level. Each cost and benefit quantified is listed in the table below. Appendix 2 provides a summary of Frontier Economics methods, which explain the valuation of some of these costs and benefits. This chapter provides a detailed description of additional costs and benefits included in this analysis and the method of quantification and monetisation. Note that these incremental costs and benefits do not all apply to each building typology.

TABLE 8: COST BENEFIT FRAMEWORK

Theme	Incremental Costs	Incremental Benefits
Operational Energy	– Electricity use – Cost of green energy – Elimination of onsite fossil fuels and natural gases – Renewable energy generation	– Reduced gas energy use – Carbon abatement
Sustainable Transport	– Retrofitting EV charging – Shared space for EV charging	– Bike parking – Active transport benefits – EV charging
Integrated Water Management	– Efficient fittings and appliances – Onsite stormwater collection	– Reduced potable water use –
Indoor Environment Quality	– Ventilation standards – Construction cost of external shading	– Openable external windows (only applicable to RES 4)
Circular Economy	– Other	– Diversion from landfill – Organic waste recovery
Green Infrastructure	– Green factor score construction cost – Non-glazed facade	– Carbon sequestration benefits – Health benefits – Reduced stormwater discharge

Source: SGS Economics and Planning (2023)

3.1 Parameters

The following parameters were applied in the cost-benefit analysis undertaken on this project. All values are, as per CBA convention, expressed in real values without cost escalation. The timeframe of the CBA is 40 years in total. As per current CBA guidelines, a discount rate of seven percent has been applied.

TABLE 9: PARAMETERS OF COST BENEFIT ANALYSIS

Parameters	Description
Values	2023, real (i.e. no escalation)
Timeframe: Construction	New buildings constructed between 2023 and 2042 (20 years)
Timeframe: Benefits	Benefits achieved by buildings described in the row above, from the period 2024 to 2062. Each building will have 20-39 years of benefits quantified, depending on construction date (ie, buildings constructed in 2023 will have benefits measured from 2024 – 2062; buildings constructed in 2042 will have benefits measured from 2043-2062.)
Discount rate	7% real, with sensitivity testing at 3% and 10%

Source: SGS Economics and Planning (2023)

3.1 Costs

SGS has not attempted to re-estimate costs for this project, instead we have updated the costs used in the Frontier analysis for growth in costs.

Treatment of construction costs

The construction costs of each building typology in the Frontier report were drawn from analysis by Hip v. Hype (2022), which were largely drawn from Rawlinsons' Australian Construction Costs Handbook 2020. The analysis estimated the total costs of construction under ESD, non-ESD and Amendment standards, for each of the assessed building typologies. The difference in construction costs between Amendment standards and base case standards (ESD or non-ESD) was used as the construction costs of the Amendment.

The costings noted that the 2020 version of the Handbook was chosen to avoid the impact of fluctuations and uncertainty in construction costs. Uprating construction costs to 2023 dollars based on CPI over this period may produce biased results, as COVID restrictions, subsidies and the invasion of Ukraine have led to a rapid surge in inflation, which has just reached an inflection point and is now in decline. Actions by the Reserve Bank to control inflation with interest rates are just starting to show an impact, retail sales falling, house prices falling and unemployment rising at the time of writing. There is a risk of a delayed impact from the interest rate rises, possibly resulting in a period of deflation or below-target inflation and slow economic growth.

Over time, SGS expects construction and appliance cost inflation to return to trend. It may do this by showing a sustained period of price inflation lower than the previous trend, or in the event of a recession, prices may show a sharp drop, then return rapidly to the previous inflation trend.

For this reason, SGS has uprated these cost estimates using a long-term 20 year CPI estimates for housing (3.2% per year) and major appliances (0.36% per year) to uprate construction costs.

Replacement of appliances

All appliances are assumed to be replaced every 15 years, by appliances that have a similar level of energy and water efficiency.

Ongoing utilities costs

The CBA adopts the same methodology as the Frontier Economics Report for calculating the operational energy benefits, with a minor change to the electricity price. Frontier Economics used the wholesale energy price as the household price of energy to monetise the benefits of energy savings. Instead of the wholesale price, this CBA will use retail prices to more accurately value the benefits in energy savings.

Identifying a suitable measure of retail electricity and gas prices proved a complex question, as the invasion of Ukraine and overall inflation pressures have resulted in significant changes to electricity prices over a short period of time. Official estimates of average retail electricity prices from AEMO and ABS are only available when relatively out of date or have no comparable gas price estimate. The Victorian Default Offer, while a useful starting point, is more expensive than offers from major gas retailers, and does not give guidance on the cost of carbon neutral power (also called carbon zero or green power).

Instead, SGS used data from the Victorian Tarriff Tracking Project by the St Vincent de Paul Society. This project regularly publishes detailed electricity and gas tariffs in Victoria to allow consumer groups to easily analyse the impact that power prices have on disadvantaged households (St Vincent de Paul Society, 2023).

- Electricity prices were estimated by averaging the single rate charge on a quarterly consumption bill of 1200 kWh for retailers and networks, excluding the supply charge. This gives a cost of 22.992c/kWh.
- Gas prices were estimated by dividing average gas costs across retailers and networks for a 63,000 Mj consumption per annum, resulting in an estimated cost of 3.24c/Mj.
- Calculating the current cost of green power (now referred to as carbon neutral power) requires some assumptions as some companies do not currently appear to offer green power options, others charge a fee that is only a small proportion of total bills (50c or $1 per week), Energy Australia offers free green power on an opt-in basis, and others only provide carbon neutral energy, at no discernible cost premium to other providers. It is reasonable to assume that new developments coming online will choose providers that do not charge a premium for carbon neutral power, however an influx of new dwellings must only be connected to carbon neutral power may cause some retailers to increase their prices. To be conservative, the analysis estimates

that green power adds a premium of 1.3c/kWh ($1 per week for green power for annual consumption of 4000kWh).

TABLE 10: COST OF CARBON NEUTRAL ELECTRICITY

Energy company	Cost of carbon neutral option
1st Energy	None advertised
AGL	$1/week gas, 50c/week electricity
Alinta Energy	Advertised, not yet available
Energy Australia	No additional cost, opt-in
Origin	$1.50/week electricity, $1/week gas
Diamond Energy	No additional cost
Powershop	No additional cost

Source: Retailer websites, accessed June 2023

Water costs were updated based on the average retail price of water from the Australian Bureau of Statistics' Water Account (ABS, 2022).

Carbon intensity of electricity generation

As wind, solar and other carbon neutral power sources make up a greater share of Victoria's overall electricity sources, the carbon intensity of electricity generation is expected to decline. By 2050, electricity generation in Victoria is expected to be carbon neutral, and no benefits of reduced electricity use or costs of green energy use have been modelled after this date.

3.2 Benefits

The following benefits were mentioned in the Frontier Economics report, but no monetary value was assigned to these benefits in the CBA. SGS revisited these based on our understanding of neighbourhood level impacts, conducting research on ways in which these benefits could be quantified and monetised for the analysis.

TABLE 11: PREVIOUSLY NON-QUANTIFIED BENEFITS

Theme	Non-quantified benefits	Reason for exclusion	Proposed solution
Operational energy	Health and wellbeing	Immaterial.	Case study review and benefits transfer method.
Sustainable transport	Increased active transport, increased uptake of EVs	Benefits dependent on wider context.	Updated and improved definition of the base case.
Integrated water management	Reduced stormwater	No expected benefit.	Case study review and benefit transfer method.
Indoor environmental quality	Health benefits	Too context-and location- specific.	Literature review
Green infrastructure	Green infrastructure, improved biodiversity	Benefits become relevant at the neighbourhood level.	Adjust study scope to include urban environment typologies.
Climate resilience	Embedded in above themes		May need to test and reconsider BaU – for discussion.

SGS has since included five additional benefits, which include increased active transport, increased uptake of EVs, reduced stormwater run offs from green cover, carbon sequestration and health benefits from increased canopy cover.

3.3 Sustainable transport

Increased active transport

There are many factors which influence an individual's decision to choose cycling as their form of commute, including the distance and terrain of their route, the quality of bike paths and roads, or personal factors such as an individual's age, gender or other personal circumstances. Insufficient bike parking, or bike parking that is perceived as insecure, and a lack of access to changing rooms and showers are listed as some of the barriers to commuters' decision to cycle (Pearson, Berkovic, Reeder, Gabbe, & Beck, 2022). Table 12 shows some of the literature that has found increasing the availability of bike parking facilities as well as showers and personal lockers to have a measurable impact on the likelihood of workers commuting by bicycle.

TABLE 12: INCREASED ACTIVE TRANSPORT – LITERATURE OVERVIEW

Source	Relevant data	Location

(Buehler, 2012)	Compared to individuals without any bicycle facilities at work, commuters with cyclist showers, clothes lockers, and bike parking at work are associated with a 4.86 greater likelihood to commute by bicycle	Washington DC (USA)
(Kaczynski, Bopp, & Wittman, 2010)	Bicycle parking availability increases the likelihood of active commuting at least once per week by 2.70 (1.40-5.21)	Manhattan, Kansas (USA)
(Kaczynski, Bopp, & Wittman, 2010)	Having showers/lockers present increases the likelihood of active commuting at least once per week by 0.86 (0.42-1.72)	Manhattan, Kansas (USA)
(Halldórsdóttir, Nielsen, & Prato, 2017)	The availability of bicycle parking in residential areas increased the likelihood of cycling to a station by a factor of 2.5	Denmark
(Bueno, Gomez, Peters, & Vassallo, 2017)	Individuals with either bicycle parking, workplace showers and lockers, or shared-use paths were 50 times more likely to cycle to work	New York-New Jersey (USA)

Source: SGS Economics and Planning, 2023

Increased use of active transport has numerous benefits for both the environment and individual health. Australian Transport Assessment and Planning (ATAP) cites a study prepared by Garrard (2009) for VicHealth that found commuter cycling to:

- Reduce all-cause mortality
- Improve physical performance particularly for people with a low initial fitness level
- Have a favourable impact on body fat markers and body muscle mass gain
- Reduce the risk of colon cancer and breast cancer in women, and improve cancer survival
- Be associated with reducing overweight/obesity (ATAP, 2023).

SGS has included the health benefits of the likely uptake in cycling, estimating the increase in commuter cycling rates from end-of-trip facilities that make cycling easier, safer and more comfortable. A worker may decide to drive to work or take public transport if they do not have a safe place to park their bike or shower after their trip. Those that walk or run may also benefit from these facilities, however, this has not been measured. SGS has accounted for the major factors that may constrain someone's ability to ride to work, such as distance to work.

While less significant, there are also benefits that have not been monetised, for example end of trip facilities could be used for workers showering after exercising, shoppers and guests using bike facilities or residents enjoying lower risks of bike theft.

Additionally, the additional uptake in cycling may also mean that fewer car trips are taken, if workers substitute their car commutes for bike commutes. This can translate to benefits such as avoided vehicle operating costs and travel time savings due to reduce congestion, potentially valued at an additional $1.15 per kilometre (TfNSW, 2022)[1]. It is not possible to determine how many car trips will be avoided, as some people may be switching from public transport or car pooling.

The annual health benefits of increased active transport have been monetised in the following way, with Table 13 summarising the assumptions used in the modelling.

$$\begin{aligned} \text{Annual health benefits} \\ &= \text{uptake of cycling to work } \times \text{population able to cycle to work} \\ &\times \text{average cycling commute distance per person per year} \\ &\times \text{health benefit per person per km} \end{aligned}$$

This has been compared against the base case, which takes ABS Census statistics on the number of workers who currently cycle within a 10km journey to work. Under the project case, it assumes that if all buildings had end-of-trip facilities, it is expected that there would be a total uplift of 6.56% of people who are able and will commute by cycling (non-ESD councils) and an uplift of 3.28% for ESD councils.[2] Note that the COVID pandemic lockdown periods changed the travel to work patterns with increased working from home, therefore the 2016 ABS data rather than 2021 data was used as a more accurate reflection of typical travel to work patterns.

TABLE 13 INCREASED ACTIVE TRANSPORT - ASSUMPTIONS OVERVIEW

Parameters	Values	Source
Benefit realised	Year where 30% of all commercial buildings has been developed. Development period: 40 years	SGS Assumptions
% of people who are able to cycle	99.20% of workers do not have a physical disability and need for assistance with core activities 76.50% of households do not have a child under the age 10 30% of people who live within a 10km cycling commute to work, which varies across SA2	ABS 2016 Census
% uplift in cycling due to the Amendment	Non-ESD Council: 6.56% ESD Councils: 3.28%	SGS Assumptions based on literature in Table 12

[1] Transport for NSW parameters on per-kilometre benefits of reduced car use and health benefits of cycling have been used in this analysis, as Victoria has no equivalent and the Federal ATAP guidelines do not go into the same level of detail. It is likely that these parameters estimated for NSW will be similar to those experienced in Victoria, due to similar population numbers in the capital city, not dissimilar population distributions and a similar public transport/car travel trips to work. Health benefits of cycling were estimated from national studies and so are applicable across Australia.

[2] This uses core findings from Buehler (2012) which suggests 8.26% of the population who are able to would commute by cycling, and that 1.7% of sample respondents indicate that they had cycle to work prior to evaluating the effect of end of trip facilities.

Parameters	Values	Source
Benefit per worker	Average commuting distance: 7.6km per week Health Benefits: $1.28 per km ($2021)	ABS 2016 Census; Transport for NSW (2022): TfNSW Economic Parameter Values

Source: SGS Economics and Planning, 2023

Increased uptake of EVs

Several studies show EV charging facilities are an influential factor in encouraging EV uptake. For example, adding a charging station (per 100,000 residents) had a greater impact on predicting EV market share than did increasing financial incentives by $1,000 (Sierzchula, Bakker, Maat, & van Wee, 2014). Table 14 shows the likely increase in EV uptake as a result of installing more EV charging facilities. However, it should also be noted that other factors such as driving range, driving mode, and car ownership also play a significant role in EV uptake (Sheng, et al., 2022)

TABLE 14: INCREASED UPTAKE OF EVS – LITERATURE OVERVIEW

Source	Relevant data	Location
(Sheng, et al., 2022)	A one-unit increase in public EV charger installation in the neighbouring areas would increase the current number of EV uptake by a factor of 15 (one-unit = a public charger point)	Auckland (New Zealand)
(Sierzchula, Bakker, Maat, & van Wee, 2014)	Each additional station per 100,000 residents that a country added would increase its EV market share by 0.12%	30 countries including Australia, New Zealand, UK, US
(Javid & Nejat, 2017)	The probability of buying a EV would increase by 1.9% for each additional charging station per 10,000 capita.	California (USA)
(Zou, Khaloei, & MacKenzie, 2020)	A 1 min reduction in walking time from slow charging to home increases the probability of buying EV by 0.009, while it is 0.004 for 1 min change in proximity to work	USA
(Sommer & Vance, 2021)	Each additional normal charging point installed in a month is associated with an increase of approximately 0.06 EVs per county per month, while the effect of a fast charger is 0.27 EVs	Germany & other countries in the EU

Source: SGS Economics and Planning, 2023
Note: Most of these studies referred to public EV chargers, but in some studies it was not clear whether the study included home or private business charging stations. Only Zhou et al (2020) distinguished between fast and slow chargers.

SGS has included this benefit, which assesses the benefit of requiring appropriate infrastructure and cabling to be installed and/or provided in residential homes. By ensuring developments are designed to support electric vehicle charging, it is expected that a greater uptake in passenger EVs will occur. The literature shows that appropriate and ample supply of charging stations is necessary for a societal transition to electric vehicles. With policy geared towards supporting a transition away from combustible engine vehicles, at-home charging is a critical success factor to the future market share. Without so, future government targets may not be so easily reached.

To avoid double counting, the impact of EV charger availability on EV uptake has only been assessed for workers at their place of work in commercial buildings. While people may typically charge at home, being able to top up during the work day via ample charging destinations, may be the deciding factor for a car purchaser to choose an EV over an internal combustion engine (ICE). This may help with smoothening the transition and produce a greater uptake to EVs.

There are other benefits that have not been captured in the modelling, including reduced air pollution. ATAP guidelines suggest there is a $7.60 pkm incremental benefit for air pollution in comparison to petrol cars, and $19.40 pkm moving away from diesel cars. Mitigating climate change effects from cars can lead to a $10.2-12.2 pkm benefit (2020 values).

The annual environmental benefits of increased EV uptake can be monetised in the following way, with Table 15 summarising the assumptions used in the modelling.

$$\begin{aligned} &\mathit{Benefits\ of\ increasing\ EV\ uptake} \\ &\qquad = (\mathit{Anticipated\ future\ market\ share} - \mathit{current\ EV\ market\ share}) \\ &\qquad \times \mathit{average\ distance\ travelled\ per\ year} \times \mathit{difference\ in\ cost\ of\ emissions} \end{aligned}$$

The scenarios are underpinned by future electric vehicle projections undertaken by CSIRO (Graham & Havas, 2021). Under the base case or ‘slow growth’ scenario, it assumes that the maximum market share of EVs will be relatively limited to 46% by 2050 due to three factors:

- The share of landlords who enable EV charging onsite;
- Off-street parking/private charging availability; and
- Public or multi-occupant building charging availability.

Their modelling allows for higher EV takeup depending on government policy implementation.

FIGURE 6 CSIRO SCENARIOS FOR ELECTRIC VEHICLE TAKEUP

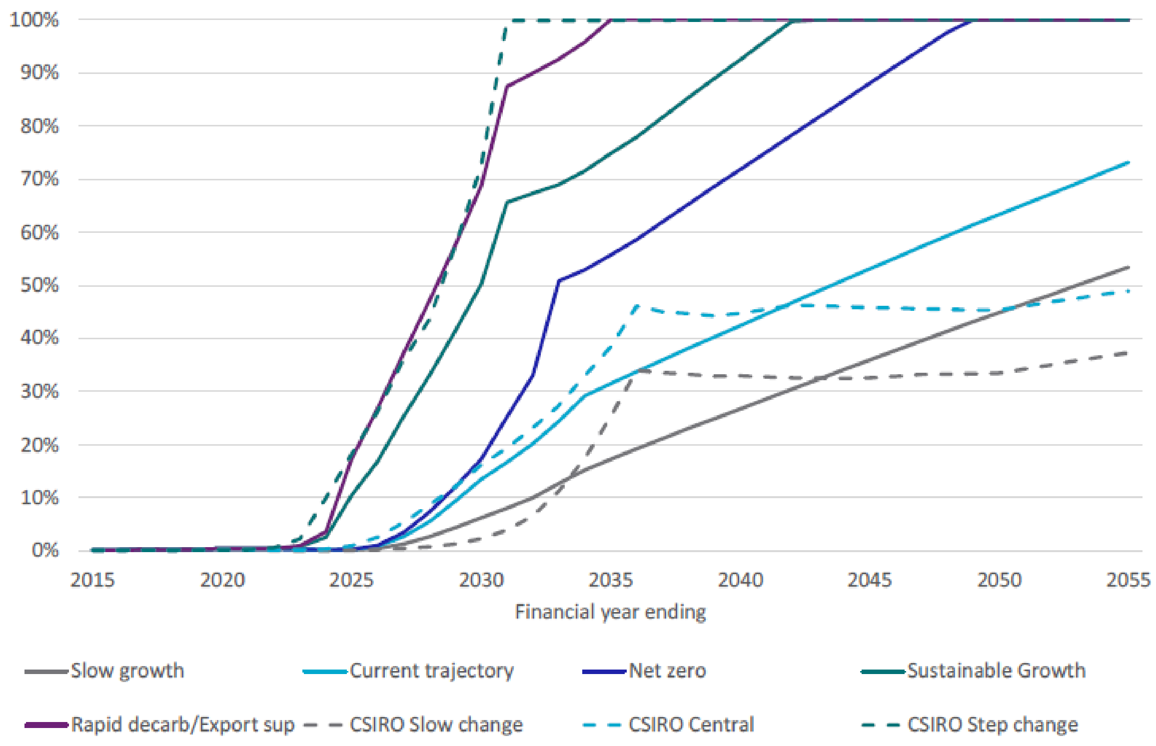


Figure 5-1 Projected sales share, all electric vehicles, compared to selected 2020 projections

Source: (Graham & Havas, 2021)

SGS has allowed the base case to be the mid-point trajectory between the 'slow growth' and 'net zero' pathways. The project case assumes a greater rate of uptake due to greater ease of accessing car charging spaces, with a maximum EV market share capped at 70%. SGS has taken the conservative approach to apply an effectiveness factor of 60% on top of the uplift, which suggests the Amendment will uplift future market share by 14% compared to the base case.

TABLE 15 INCREASED UPTAKE OF EVS- ASSUMPTIONS OVERVIEW

Parameters	Values	Source
Benefit realised	Year where 30% of all commercial buildings have been developed in the neighbourhood. Development period: 40 years	SGS Assumptions
Population no. and distribution	2,956,111 across 7,000 neighbourhoods (2022) 44.80% of Victoria's population	SGS Small Area Model
Car ownership rates	52-73% per person varied across LGA 74% of motor vehicles are passenger cars	ABS Motor Vehicle Census (2016 & 2021): Motor Vehicle Ownership

Electric vehicle rates	0.13% of light vehicle fleets are EVs 80% at-home charging reliance	ABS Motor Vehicle Census (2021): Motor Vehicle Ownership; SGS Assumption
Benefit per EV ownership	Average kilometres travelled in a year (VIC): 12,000km Avoided emissions of petrol car (WTT emissions)(incremental): $17.9/1,000km ($2020)	ABS Survey of Motor Vehicle Use (2020) (Table 10); Australian Transport Assessment and Planning (2016): PV5 Environmental parameter values (Table 5-22)

Source: SGS Economics and Planning, 2023

3.4 Green infrastructure

Overview

Green infrastructure refers to “all vegetation that provides environmental, economic and social benefits such as clean air and water, climate regulation, food provision, erosion control and places for recreation” (CSIRO, n.d.).

INFOGRAPHIC – THE SUITE OF BENEFITS THAT TREES CREATE

Green infrastructure enhances people’s experience and appreciation of a location, as evident in with the increases in median property prices in leafy suburbs. For example, a study of 23 suburbs in Perth found a 4.27 per cent increase in median property price per broad-leaved tree on the street verge (Pandit, Polyakov, Sorada, & Moran, 2013). Over on the east coast of NSW in Blacktown, a 10 per cent increase in canopy coverage showed a 7.7 per cent increase in property value (AECOM, 2017). This flow-on benefit has been driven by a range of outcomes from green cover/spaces, as individuals and communities can enjoy[3]:

- Temperature regulation, including avoided heat-related illness, household electricity costs and/or greenhouse gas emissions;
- Carbon sequestration;
- Improved health and well-being, including mental and physical health benefits from improved air quality and uptake in active transport; and
- Reduced stormwater run-off.

Not all these benefits have been modelled for as they may overlap with benefits in other categories. These have been articulated in their relevant sections, along with the corresponding evidence and quantification methods.

Carbon sequestration

One of the most coveted benefits of vegetation is its ability to remove and store carbon dioxide from the atmosphere (sequester carbon) and store it in their biomass and soils. The rate of carbon sequestration is species-specific and depends on a tree's growth rate, wood density and location.

Additional vegetation planted will see carbon dioxide absorbed back from the atmosphere over time, which is essential to mitigate the impact of climate change. Investing in carbon sequestration technology is crucial for achieving a low-carbon, sustainable and resilient future. Green infrastructure, such as urban forests, parks, street trees and green roofs can sequester carbon while providing additional economic and social benefits. By increasing carbon sequestration through green infrastructure, cities and communities can not only reduce their carbon footprint but also create more attractive and livable cities that attract investment and support economic growth.

SGS has included the sequestration benefit in the modelling. Under the Amendment, residential and commercial properties will be required to maintain a certain standard in considering green infrastructure, such as canopy and vegetation. As parameters used in the model are associated with the benefits of trees, SGS has only assessed carbon sequestration from this source. There are additional benefits from other types of vegetation that may be used, including shrubs, vines and so forth.

The Amendment will also ensure that coverage today does not continue to deteriorate with the development of cities and rising population. Neighbourhoods in regions where there have been low rates of vegetation today, will see the greatest benefit.

[3] Amenity benefit is not considered individually in the CBA as it is captured by the other benefits (NSW Department of Planning and Environment, 2022)

The benefits of carbon sequestration can be monetised in the following way, with Table 16 summarising the assumptions used in the modelling.

$$Benefits\ of\ carbon\ sequestration = uplift\ in\ area\ of\ tree\ planting\ (m^2)\ \times carbon\ sequestered\ per\ m^2 \times CO_2 - e\ per\ unit\ of\ carbon \times cost\ per\ kilogram\ of\ CO_2 - e$$

The base case assumes that the trend of tree cover on commercial and residential land will continue to slowly decline due to lagged legislation. This is largely based on evidence produced by the Centre of Urban Research, RMIT, which assessed the change in urban vegetation cover across different land uses and by broad regions (Hurley, et al., 2019). The project case considers if rates of tree coverage were maintained to a certain level across all CASBE councils. As such, if councils today have a rate below this threshold, they will see increased canopy cover as the buildings become redeveloped over time and plantable areas come online.

Also note that while this has been calculated as a neighbourhood benefit, this is the benefit to society as a whole in adapting to climate change. The benefits of carbon sequestration are largely driven by the cost of carbon ($123 - $150).

TABLE 16: CARBON SEQUESTRATION - BENEFIT OVERVIEW

Parameters	Values	Source
Land for re-development	Land size varied by neighbourhood 80% developable land 20% considered for roads, pathways and the like	SGS Assumptions
Base case - Tree canopy by land-use	Non-ESD Councils - Residential: 5.2-18.2%; Commercial: 3.9-7.2% ESD-Councils - Residential: Whatever is greater, current cover & 10%; Commercial: Whatever is greater, current cover & 5%	(Hurley, et al., 2019)
Plantable areas	10 sqm per tree	Clean Energy Regulator (2013) based on tree planting project in Leongatha, Victoria
Carbon sequestrated per year	0.24 kg/sqm in years 1-5 0.61 kg/sqm in years 5-10 0.47 kg/sqm in years 10-20 0.3 kg/sqm year 20 onwards Reduction in effectiveness in developed (ie Metro Melbourne) areas: 30% PV at 7% discount rate: 2.87 kg/sqm	Clean Energy Regulator (2013) based on tree planting project in Leongatha, Victoria; SGS Assumption
Survival rate of trees	90% survive	SGS Assumption

CO2-e per unit of carbon	44/12	-
Benefit per tree	$123-150 Co2-e per kilo	(NSW Treasury, 2023)

Source: SGS Economics and Planning, 2023

Improved health and wellbeing

The physical health benefits of vegetation can be quantified as avoided healthcare costs, borne by the individual, the community and the government. The visual amenity of trees is linked to mental health and wellbeing outcomes, with research revealing a connection between exposure to plants and reduced feelings of pain, anxiety and fatigue (Soderlund & Newman, 2015). There is a growing body of international literature demonstrating the link between green infrastructure with health and well-being, with some described in Table 17.

TABLE 17: IMPROVED HEALTH AND WELLBEING – LITERATURE OVERVIEW

Source	Relevant data	Location
(Department of Environment, Land, Water and Planning, 2020)	Research shows that the shade provided by trees can contribute to a more active lifestyle and lower incidences of heat stress.	Australia
(Department of Environment, Land, Water and Planning, 2020)	Trees also provide an efficient air regulation service; by sequestering carbon and reducing the overall concentration of greenhouse gases in the atmosphere, they intercept airborne particulates and reduce smog.	Australia
(Nowak, Hirabayashi, Bodine, & Greenfield, 2014)	Computer simulations with local environmental data reveal that trees and forests in the comparable United States removed 17.4 million tonnes of air pollution in 2010, with human health effects valued at 6.8 billion U.S. dollars. Health impacts included the avoidance of more than 850 incidences of human mortality and 670,000 incidences of acute respiratory symptoms. Most of the pollution removal occurred in rural areas, while most of the health impacts and values were within urban areas.	United States of America

Source: SGS Economics and Planning, 2023

SGS has included this benefit in the modelling. Similar to carbon sequestration, residential and commercial properties will be required to maintain a certain standard in considering green infrastructure, such as canopy and vegetation. This measures the expected health benefits per sqm designated for all vegetation cover. To avoid double counting, only the avoided healthcare cost for governments have been incorporated. However, there are additional health benefits such as benefits to workers and residents with the provision of more green space. This may take the form of a generation of well-being, and reduced air and heat stress/illnesses, which has not been approached.

Similar to the previous benefit, the Amendment will ensure that coverage today does not continue to deteriorate with the development of cities and rising population. Neighbourhoods in regions where they have been low rates of vegetation today, will see the greatest benefit.

The benefits of reduced healthcare spending can be monetised in the following way, with Table 18 summarising the assumptions used in the modelling.

$$\begin{aligned} &Health\ benefits\ from\ green\ infrastructure \\ &\quad = uplift\ in\ green\ cover\ \times residents \\ &\quad \times avoided\ healthcare\ spending\ on\ anxiety\ and\ depression\ per\ person \end{aligned}$$

In the incremental project case, it assumes that the current vegetation cover will reach a minimum standard of 40%. For non-ESD councils, there would be a complete uplift to reach those rates over a 40-year development period. Though there is a smaller uplift for ESD Councils as they may already have legislations tied into their policies to date. SGS has considered this uplift may be halved for these councils.

The benefits draw on from Cox et al. (2017), which shows:

- A 1 percentage point decline in anxiety and stress cases for every 1 per cent increase in canopy cover over 20 per cent
- A 0.8 percentage point decline in depression cases for every 1 per cent increase in canopy cover over 20 per cent.

TABLE 18 HEALTH BENEFITS – BENEFIT OVERVIEW

Parameters	Values	Source
Spending on anxiety and depression	Total cost of mental health services (VIC): $1,820,944,070 per annum % of cases/spending on anxiety and stress: 10.5% % of cases/spending on depression: 5.6%	Australian Instiute of Health and Welfare (2022); Royal Australian & New Zealand College of Psychiatrists (2016)
Population (no. and distribution)	Varied by neighbourhood	SGS SAM

Source: SGS Economics and Planning, 2023

Improved stormwater management

Green infrastructure can have a number of benefits for improving stormwater management. Trees, shrubs, grassy areas, green roofs and green walls can all have benefits in reducing the costs of stormwater treatment, consuming excess grey water and reducing the risk of flooding. Plants intercept rainfall, slowing down runoff and reducing peak rainfall flows. A stormwater offset is a financial contribution paid by residential developers to use for stormwater management works to be undertaken in another location. These works ‘offset’ stormwater impacts not treated within the development.

Collecting stormwater reduces pressure on both builders and city planners to upgrade stormwater infrastructure to avoid flash flooding during heavy rainfall events.

In addition to this, Melbourne Water places a value of removing nitrogen from water at $6,645 per kilogram of nitrogen. Rainfall that enters the stormwater system will need to have the nitrogen removed; green roofs can absorb the nitrogen.

TABLE 19: IMPROVED STORMWATER MANAGEMENT – LITERATURE OVERVIEW

Source	Green infrastructure and water management	Location
(Zheng, Szota, Fletcher, Williams, & Farrell, 2019)	A 100 mm deep extensive green roofing in Melbourne can intercept between 86–92% of annual rainfall	Victoria
(CoM, 2019)	Lifetime benefits of nitrogen removal per square metre of green roof range from $70.87 to $115.17	Victoria
City of Greater Geelong (2014) Urban Forest Strategy	Analysed 1,112,375 square metres of canopy cover leads to the reduction of 8,456 cubic metres of stormwater annually, which is $22,520 in avoided stormwater management costs (2022 dollars). This roughly equates to $0.02 annual avoided costs per square metre of canopy cover.	Geelong

Source: SGS Economics and Planning, 2023

SGS has valued this benefit of the anticipated uplift in canopy cover of new developments. It takes the rationale and base assumptions of the health benefits from green infrastructure, in which a certain standard of green infrastructure will be maintained. This benefit assesses both commercial and residential developments.

The benefits of improved stormwater management can be monetised in the following way, with Table 20 summarising the assumptions used in the modelling.

$$\begin{aligned}&Improved\ stormwater\ management\ from\ green\ infrastructure\\ &\qquad = uplift\ in\ tree\ canopy \times\ avoided\ cost\ of\ stormwater\ management\ per\ sqm\end{aligned}$$

The base case and project case draw on the same approach as discussed in ‘Carbon sequestration’.

TABLE 20: IMPROVED STORMWATER MANAGEMENT - BENEFIT OVERVIEW

Parameters	Values	Source
Uplift in tree canopy	As calculated in ‘Carbon Sequestration’	

Benefits per sqm of plantable space	Avoided stormwater management: $3.615 per sqm/annum ($2019) Nitrogen removal: $0.91 per sqm/annum ($2019)	City of Melbourne (2019): Valuing Green Guide: Green Roofs, Walls and Facades

Source: SGS Economics and Planning, 2023

3.5 Summary of benefit measures

The table below summarises the quantified benefits used in the Frontier Economics report, and the benefits that SGS has quantified in this analysis.

TABLE 21: SUMMARY OF BENEFIT QUANTIFICATION METHODS

Benefit	Monetised by Frontier	Monetised by SGS	Not possible to quantify	Too minor
GHG emission reduction from buildings	*	*		
Reduced energy use	*	Retail pricing		
Avoided health costs of electricity generation	*	*		
Reduced potable water use	*	Retail pricing		
Reduced embodied carbon	*	*		
Recovery of organic waste	*	*		
Residual value	*	*		
Increased active transport (esp cycling)		*		
Increased uptake of EVs		*		
Improved air quality in buildings				*
Carbon sequestration		*		
Improved health – neighbourhood effects		*		
Reduction in stormwater treatment costs		*		
Infrastructure savings - paths				
Increased biodiversity				

Circular economy				*

3.6 Benefits that have not been quantified

Several benefits that are highly likely to arise from the project have not been quantified in this analysis, due to a lack of data or risks of double counting with other benefits.

Indoor environmental quality

Improvements to building quality have been shown to improve several areas of worker well-being and productivity due to temperature control and thermal comfort. As outlined in Table 22, there is sufficient literature evidence to prove that improved building and office requirements increase workplace productivity.

As there is an association between improved building quality with thermal comfort at the worker level, it is reasonable to assume there is a benefit at the residential level with improved thermal comfort. For example, research has shown that better-insulated houses are associated with increased bedroom temperatures in the winter and decreased humidity, along with lower energy consumption (Howden-Chapman, Matheson, Crane, Viggers, & Cunningham, 2007). This also led to lower reported wheezing, days off school and work, and a reduction in doctor visits.

While there is strong evidence that building for improved thermal comfort and air quality leads to improved productivity for workers and improved health for residents, these studies compare old buildings with new or newly renovated buildings, not new buildings and new buildings to a higher standard. Comparing a new building with higher standards to one with lower standards is unlikely to result in measurable improvements to health and productivity. This benefit has therefore not been quantified and monetised.

TABLE 22: INDOOR ENVIRONMENTAL QUALITY – LITERATURE OVERVIEW

Source	New building on workplace productivity	Improvement in productivity
(BPIE, 2018)	Improved air quality	0.8% increase per 1 litre per second per person airflow increase
(BPIE, 2018)	Improved temperature control	3.6% increase per 1 degree Celsius temperature reduction when overheating
(BPIE, 2018)	Improved lighting	0.8% increase per 100 lux increase in light level
(Pilcher, Nadler, & Busch, 2002)	Thermal comfort	14.88% decrease in performance – temperature above 32.22 degrees C

(Pilcher, Nadler, & Busch, 2002)	Thermal comfort	13.91% decrease in performance – temperatures under 10 degrees C
(Lan, Wargocki, Wyon, & Lian, 2011)	Thermal comfort (warmer temperatures)	Evidence of performance decline when temperatures increased to 30 degrees C from 22 degrees C
(World Green Building Council, 2014)	Indoor air quality	8%-10% increase in performance with improved air quality
(World Green Building Council, 2014)	Thermal comfort – cooler temperatures	4% performance increase, comparing 23 degrees to 15 degrees
(World Green Building Council, 2014)	Thermal comfort – warmer temperatures	6% performance increase comparing 21 degrees to 30 degrees
(Seppanen, Fisk, & Faulkner, 2004)	Improved temperature control	2% decrease in performance per degrees C on temperatures above 25 degrees C

Source: SGS Economics and Planning, 2023

Infrastructure savings – paths and roads

While not monetised in the analysis, green infrastructure can lead to a reduction in energy costs. Urban designs and property plans that allow for large trees can shade nearby roads. Reducing urban heat can ensure greater longevity in infrastructure, and can result in lower road and path maintenance costs through shading bitumen.

As the climate changes, extreme heat can result in bitumen degrading more rapidly. Shade from trees can keep the bitumen away from direct sunlight and reduce the extreme heat that results in rapid ageing. Moore (2009)[4] estimated that shading bitumen footpaths with trees would extend the life of footpaths, with an estimated annual value of $450 per square metre of shaded footpath. Though, small patches of shade over a footpath do not represent real savings, with savings only realised when extensive and contiguous shade occurs[5].

Requirements for minimum levels of green cover, particularly trees, could provide shade to public paths and roads. However, this may be difficult to project as the evidence shows that there are several variables, including tree type, the extent of cover and the level of sun received by the path, all of which are challenging to reasonably assume.

TABLE 23: INFRASTRUCTURE SAVINGS – LITERATURE OVERVIEW

Source	Green infrastructure and water management	Location

[4] Moore, G M (2009) People, Trees, Landscapes and Climate Change, in Sykes H (Ed) Climate Change On for Young and Old, p 132-149. Future Leaders, Melbourne

[5] Moore, G M (2011) The Value of Urban Trees during Climate Change, Proceedings of the 87th Annual Conference of the

Moore (2009)	Shading bitumen footpaths with trees would extend the life of footpaths, with an estimated annual value of $450/sqm of shaded footpath	Adelaide
McPherson (2005) [6]	Tree shading is partly responsible for reduced pavement fatigue and damage, with shade from large hackberries saving $7.13/sqm over 30 years compared to an unshaded street	California

Temperature regulation

There may be increased health and comfort impacts through the uptake of green infrastructure. This is likely to have benefits for both occupants of buildings and people utilising spaces in close proximity. However, the former has already been considered in the health benefits, and it will be difficult to separate the benefits. This has also been considered in operational energy benefits. Though not monetised, green infrastructure can provide great benefits to the general public in high pedestrian locations, eg retail space, which can enjoy more comfortable temperatures.

There is also extensive evidence that trees regulate temperatures by creating shade in summer and serving as a wind break in winter. These benefits manifest in several ways, leading to:

- Avoided health costs (avoided heat-related mortalities)
- Avoided household electricity costs
- Avoided greenhouse gas emissions.

A summary of key findings from national and international studies is shown in Table 24. Notably, the efficiency of trees (for temperature regulation) depends on a myriad of factors such as climate, tree species and the tree's location respectively to a home and/or sun orientation. While summer shading is well-recognised across the literature, the temperature regulation benefits in winter are ambiguous. On one hand, trees are effective windbreaks and can reduce cool winds but on the other, they reduce exposure to winter sun (Akbari, 2009).

TABLE 24: TEMPERATURE REGULATION – LITERATURE OVERVIEW

Source	Relevant data	Location
(AECOM, 2017)	Doubling leaf canopy would lead to 28 per cent fewer heat-related deaths.	New South Wales (AUS)
(AECOM, 2017)	Air temperate was 4°C lower in streets with 28 per cent canopy coverage than in streets with 20 per cent canopy coverage.	New South Wales (AUS)

[6] McPherson, E.G.; Muchnick. J. 2005. Effects of street tree shade on asphalt concrete pavement performance. Journal of Arboriculture 31(6): 303-310

(Local Government NSW, 2016)	Within 10 years of planting, street trees already have a significant cooling effect. At 20 years of age, street trees would save a household 10,651 kWh per annum. At 40 years, street trees will save a household 17,700 kWh per annum.	New South Wales (AUS)
(Ossola, Staas, & Leisham, 2020)	The number of private gardens and the vegetation cover within these gardens both contributed significantly to providing widespread cooling benefits across the Western Adelaide region with localised reductions in land surface temperatures of up to 5-6°C compared to non-vegetated areas and land parcels.	South Australia (AUS)
(Akbari, 2009)	Trees provide 15-35% energy saving benefits from summer cooling.	California (USA)
(Simpson & McPherson, 1996)	Tree planting would reduce energy used in summer cooling by up to 50 per cent.	California (USA)
(Tong, et al., 2021)	$79.5 million worth of hospital costs in Perth were attributable to heat in the period between 2006 and 2012.	Western Australia (AUS)

Source: SGS Economics and Planning, 2023

Improving biodiversity

SGS has not valued the benefits of green infrastructure in improving diversity, however, green infrastructure at the neighbourhood level has the potential to improve habitat to support biodiversity in cities. Trees provide habitat for birds and mammals such as possums and shade for ground dwelling species, and shrubs provide shelter for small animals. Flowering plants provide sustenance for pollinating insects. At the ground level, biodiversity benefits are best achieved where trees and green spaces are established in clusters linked by corridors, so animals can move easily between habitats.

Green roofs can provide spaces for biodiversity to thrive, by providing a location for endangered plants to grow unthreatened by predators. They can also provide habitat for fauna, including birds, insects and invertebrates. Generally, green roofs provide greater benefits of biodiversity in buildings that are only a few stories tall or less – very tall buildings with green roofs have fewer biodiversity benefits as fauna cannot travel from building to building.

Neighbourhood level green infrastructure is very important in supporting biodiversity – twenty adjacent sites with ample tree cover/green infrastructure will have more than 20 times the biodiversity benefits of a single green building surrounded by 19 concreted sites.

Biodiversity benefits have typically been valued using Willingness to Pay (WTP) or choice modelling surveys, which estimate how much people value the protection of endangered species. However, most such studies are focused on saving cute animals, predominantly mammals[7]; or they are focused on

[7] Pandit, R., Subroy, V., Garnett, S. T., Sander, K. K., & Pannell, D. (2018). A review of non-market valuation studies of threatened species and ecological communities, Report to the National Environmental Science Programme. Canberra: Department of the

animals that do not have city habitats. Drawing on these to estimate biodiversity values for urban green infrastructure may be problematic, as the less familiar, less cute, creatures that are likely to add to city biodiversity in green infrastructure will not generate the same willingness to pay, regardless of their importance to the ecosystem.

While the benefits of green infrastructure certainly exist, the current valuation methods for biodiversity are unsuitable for valuing the benefits of urban green spaces.

TABLE 25: IMPROVED BIODIVERSITY - LITERATURE OVERVIEW

Source	Relevant data	Location
Ayers and Rehan (2021) [8]	Abundant, diverse green plant life in cities in public and private green spaces can support bees and pollinators	Canada
City of Melbourne (2019)	Green roofs can provide a safe location for protection of endangered species that might otherwise be subject to predation by rabbits or other pests	Melbourne
Dumsday (2007)[9]	Increased biodiversity from new tree plantings worth $22/ha/year (assumes 100ha of trees resulting in 0.1% increase in survival of endangered species)	Victoria
Dumsday (2007)	Increase of 100 breeding pairs of endangered or threatened parrots valued at Melbourne: $4.39 hh/yr, Bairnsdale $8.39 hh/yr using choice modelling	Victoria
Jacoksson & Dragun (2001)[10]	Contingent valuation study showing willingness to pay $29.18 - $75.55/household/year in taxes to save the Leadbeater's possum	Australia

Source: SGS Economics and Planning, 2023

Reduction in car ownership

Increasing the prevalence of secure bike parking in residential and non-residential buildings is likely to lead to increased cycling, as residents are comfortable purchasing bikes knowing they can be securely stored both at home and at most of their intended destinations. This may result in some people choosing to reduce the number of cars the household owns, for example a couple may decide to only have one car rather than two if their home and employment has secure bike parking. This would save

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[9] Dumsday, R. (2007). Employing benefit transfer in environmental applications - the view from the real world. Environmental Economic Research Hub Workshop on Benefit Transfer: Practice and Prospects. Canberra.

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the additional fixed costs of car ownership, such as registration and insurance, as well as the per-kilometre costs such as petrol.

4. Cost benefit analysis results

This section presents the cost benefit analysis results. It contrasts the costs and benefits generated from the proposed changes in order to assess whether a net gain in community welfare will be generated.

4.1 Performance measures

A definition of net present value and benefit cost ratio and how to interpret them is provided below.

TABLE 26: COST BENEFIT ANALYSIS PERFORMANCE MEASURES

Performance measure	Estimation method	Decision rule
Net Present Value (NPV)	A number generated by deducting the present value of the stream of costs from the present value of the stream of benefits, (with the present value of costs and benefits determined by using an appropriate discount rate).	– Accept options with a positive NPV – Reject options with a negative NPV – The greater the NPV the better.
Benefit to Cost Ratio (BCR)	Ratio of discounted present day benefits over discounted present day costs.	– Accept options with a BCR > 1 – Reject options with a BCR < 1 – The greater the BCR the better.

Source: SGS Economics and Planning (2023)

4.2 Cost benefit results

The impacts of the Amendment have been classified into six categories:

- Operational energy: This covers the reduction in electricity and gas used as a result of more energy efficient construction, avoidance of gas for energy and more energy efficient appliances. The benefits of operational energy include the reduction in electricity and gas costs and the reduction in associated greenhouse gas emissions. The costs include the higher costs of construction to achieve energy efficiency and the cost premium of energy efficient appliances.
- Sustainable transport: This covers provisioning new buildings to support use of EVs, walking and cycling. The benefits include the neighbourhood benefits of higher uptake of electric vehicles and an increase in the share of people cycling to work in neighbourhoods with a higher share of Amendment buildings. The costs include the upfront costs of installing EV charging infrastructure, bike parking and end of trip facilities.
- Integrated water management: The reduction in potable water use and improved quality of stormwater discharging from providing water efficient fixtures and appliances, and for rainwater

harvesting where suitable. The benefits are a reduction in potable water consumption and the value of recovered organic waste.

- **Indoor environmental quality**: Improvements in external shading, ventilation and sunlight access. While this is expected to have benefits it was not possible to quantify these except at a very minor level.
- **Circular economy**: The costs of implementing a program of resource recovery and using reusable materials, which are offset by the benefits of avoided landfill costs and externalities, and costs avoided in using recycled materials.
- **Green infrastructure**: This includes allowing for higher levels of canopy cover when a buildng is developed, and includes costs such as reducing building footprints to allow for more trees, or sturdier roofs to allow for green roofs and gardens. The benefits include carbon sequestration, improved mental health and reduced water treatment costs. Importantly, the benefits do not include avoided heat related illnesses, which a recent SGS study for the City of Greater Geelong shows to be a major benefit. This was not included to avoid any double counting with improved indoor environment quality.

The results of the CBA are shown in the table below.

TABLE 27: COST BENEFIT ANALYSIS RESULTS ($ BILLION, 2023 DOLLARS)

Discount rate	7%		3%		10%	
	Costs	Benefits	Costs	Benefits	Costs	Benefits
Operational Energy	$1.32	$8.09	$1.49	$15.23	$1.42	$5.48
Sustainable Transport	$0.37	$0.73	$0.49	$1.36	$0.30	$0.51
Integrated Water Management	$0.11	$0.44	$0.35	$0.95	$0.06	$0.27
Indoor Environment Quality (IEQ)	$2.79	$-	$3.78	$-	$2.30	$-
Circular Economy	$0.94	$1.46	$1.28	$2.96	$0.77	$0.96
Green Infrastructure	$7.82	$9.05	$10.57	$15.81	$6.46	$6.27
Total impacts	$13.36	$19.78	$17.96	$36.30	$11.31	$13.49
Net present value	**$6.42**		**$18.34**		**$2.18**	
Benefit cost ratio	**1.48**		**2.02**		**1.19**	

Source: Modelling by SGS Economics and Planning (2023)

The CBA shows that under the default 7% discount rate, the total net present value of applying the Amendment to 20 years' worth of construction amounts to $6.42 billion dollars across Victoria; or a BCR of 1.48, which means that $1 spent in Amendment upgrades produces $1.48 worth of benefits.

Changing the discount rate to 3% or 10% impacts the results, but not substantially. Both discount rates produce a positive net benefit.

For long term projects which are expected to have substantial upfront costs and benefits continuing for a long time (30+ years into the future) with low levels of uncertainty, then a lower discount rate of 3% may be more appropriate than 7%, particularly when environmental impacts which may affect humanity for decades or centuries are affected, such as through climate change. Lower discount rates ensure that significant and reasonably certain impacts that occur more than thirty years into the future are not discounted into insignificance.

4.3 How the components of costs and benefits stack up

The CBA is structured so that the total costs of achieving a particular outcome can be directly compared to the value of that outcome.

Operational energy

The greatest contributor to total benefits is Operational Energy, namely the cost savings from reductions in energy use and the associated reduction in carbon emissions benefits. It provides $8.09 billion in benefits for $1.32 billion in costs. Building for energy efficiency is costly upfront, but is more than offset by the reduction in energy costs and associated carbon emissions.

The benefits exceed the costs in this analysis by a greater amount than in the Frontier analysis as this analysis calculated the benefits based on more recent estimates of the cost of carbon, updated prices of gas, electricity and carbon neutral power and the use of retail rather than wholesale prices to capture effects on the end user. This analysis also assumes that machinery and equipment are replaced every 15 years with the same degree of energy efficiency, relative to the base case, over time even as appliances are replaced. Note that this analysis also assumes that electricity generation will be carbon neutral by 2050, therefore there will be no quantified benefits of carbon mitigation beyond 2050.

Sustainable transport

The present value of costs of investing in sustainable transport standards is $370 million, for a benefit of $730 million. This includes the benefits of an increase in the uptake of electric vehicles and in bicycle commuters. This benefit only takes into account estimates of induced cycling and EV take-up from the infrastructure changes; it does not take into account greater convenience and potentially reduced costs for people who choose to cycle or drive EVs even without the Amendment. The Frontier analysis did not calculate the benefits of sustainable transport.

Integrated water management

The present value of costs of integrated water management is $110 million, for a benefit of $440 million, as a result of costs savings from potable water consumption. The benefits exceed the costs in this analysis by a far greater amount than in the Frontier analysis as this analysis calculated the benefits using retail rather than wholesale water prices, in order to capture the savings that end users experience rather than those to the wholesaler or distributor of water. This analysis also allows for higher costs associated with the regular replacement of appliances every 15 years, assuming the same degree of water and energy efficiency relative to the base case for the new appliances.

Indoor environment quality

The present value of costs of IEQ is $2.79 billion, with no benefits. The benefits were not calculated as there was a risk that they could double count the benefits of energy cost savings, calculated as part of the Operational Energy estimate.

Circular economy

The present value of circular economy costs amounts to $940 million, with a present value of benefits of $1.46 billion. SGS did not make changes to Frontier's method of calculating circular economy benefits, so the costs and benefits are proportionate across both analyses.

Green infrastructure

Green infrastructure makes the largest contribution to overall costs and benefits. The present value of green infrastructure costs is $7.8 billion, with a present value of benefits of $9 billion. The Frontier analysis did not quantify this benefit. The benefits come from increased absorption of carbon, improved mental health of residents and reduced water treatment costs.

4.1 Sensitivity analysis

Sensitivity analysis involves testing the CBA with more conservative and more generous assumptions to allow for the possibility that some estimates of values may turn out to be too high or too low, and allows for a means of risk reduction.

This report has conducted sensitivity analysis on the following scenarios:

- Using a construction and appliance CPI reflecting the COVID years rather than the long term average
- Lower and higher cost of carbon
- Lower turnover/refurbishment rates of buildings leading to slower neighbourhood effects

Higher construction cost inflator

This sensitivity test allows for a higher construction cost inflator to be used, namely it assumes an increase in construction costs and appliance costs of 50% since 2020. A high increase in the construction cost inflator has been used due to the recent volatility on construction prices.

The impact of this is to increase the present value of costs of the Amendment by $5 billion to $18.38 billion – a significant increase. However, it still produces a net present value overall of $1.69 billion, with a BCR of 1.09. Operational Energy, Sustainable Transport, Integrated Water Management and

Circular Economy components of the Amendment still provide positive returns, but the Green Infrastructure component's new level of costs exceed benefits.

TABLE 28: HIGHER CONSTRUCTION COST INFLATOR ($ BILLION, 2023 DOLLARS)

Discount rate	7%	
	Costs	Benefits
Operational Energy	$1.77	$8.09
Sustainable Transport	$0.50	$0.92
Integrated Water Management	$0.32	$0.44
Indoor Environment Quality (IEQ)	$3.81	$-
Circular Economy	$1.29	$1.46
Green Infrastructure	$10.69	$9.15
Total impacts	$18.38	$20.07
Net present value	**$1.69**	
Benefit cost ratio	**1.09**	

Source: Modelling by SGS Economics and Planning (2023)

Lower carbon price

This sensitivity test considers the impact of higher and lower carbon prices of setting the carbon price at $75/tonne, as used in the Frontier analysis, and of $308/tonne, as used in the Nature analysis.

This results in the overall benefits falling substantially, to a net present value of $1.63 billion and a BCR of 1.12. Increasing the carbon price to $308/tonne results in a NPV of $24.06 billion and a BCR of 2.08. This highlights the importance of the cost of carbon as a contributor to overall benefits.

Removing the cost of carbon altogether results in the BCR for the Amendment falling to 0.58, and the net benefits turn to a net cost of $5.59 billion.

TABLE 29: LOWER COST OF CARBON SENSITIVITY TEST ($ BILLION, 2023 DOLLARS)

Discount rate	$75/tonne	$308/tonne

	Costs	Benefits	Costs	Benefits
Operational Energy	$1.32	$6.83	$1.32	$12.96
Sustainable Transport	$0.37	$0.73	$0.37	$0.73
Integrated Water Management	$0.11	$0.44	$0.11	$0.44
Indoor Environment Quality (IEQ)	$2.79	$-	$2.79	$-
Circular Economy	$0.94	$1.46	$0.94	$1.46
Green Infrastructure	$7.82	$5.53	$7.82	$21.83
Total impacts	$13.36	$14.99	$13.36	$37.42
Net present value	**$1.63**		**$24.06**	
Benefit cost ratio	**1.12**		**2.80**	

Source: Modelling by SGS Economics and Planning (2023)

Changes in energy prices

Savings in energy costs are a major benefit of this Amendment. Under the Amendment, households and businesses are expected to become more energy efficient. However, the switch away from gas means that some households and businesses will find their electricity usage increases overall. The falling price of green power since the Frontier analysis, with some retailers providing green power for minimal to no cost, has also had an impact.

This sensitivity test shows how benefits are sensitive to the relative prices of utilities. If gas prices fall when electricity costs stay the same or increase, then net present values fall. Increasing prices of either green electricity, or all electricity, results in a substantial fall in both NPV and BCR.

TABLE 30: CHANGES IN ENERGY PRICES SENSITIVITY TEST ($ BILLION, 2023 DOLLARS)

	Gas prices halve, electricity remains the same	Green energy 4c/KwH more expensive than regular	All electricity prices double
Net present value	$5.28	$5.70	$6.84
Benefit cost ratio	1.40	1.40	1.50

Source: Modelling by SGS Economics and Planning (2023)

These sensitivity tests show that the results are highly sensitive to the cost of carbon and the relative cost of energy prices. However, it would take a substantial shock to energy prices AND the cost of carbon for the net benefits of the Amendment to turn negative.

5. Financial case studies

While Victorians are generally supportive of the idea of taking steps to reduce greenhouse gas emissions, most stakeholders who are looking to develop, buy or rent a home or business premises will want to know how it will affect their hip pocket.

This chapter considers four case studies of developments, and identifies the costs and benefits that will affect stakeholders, and the extent to which each will be better or worse off. The three key differences in impacts between these financial case studies and a cost benefit analysis is that these case studies:

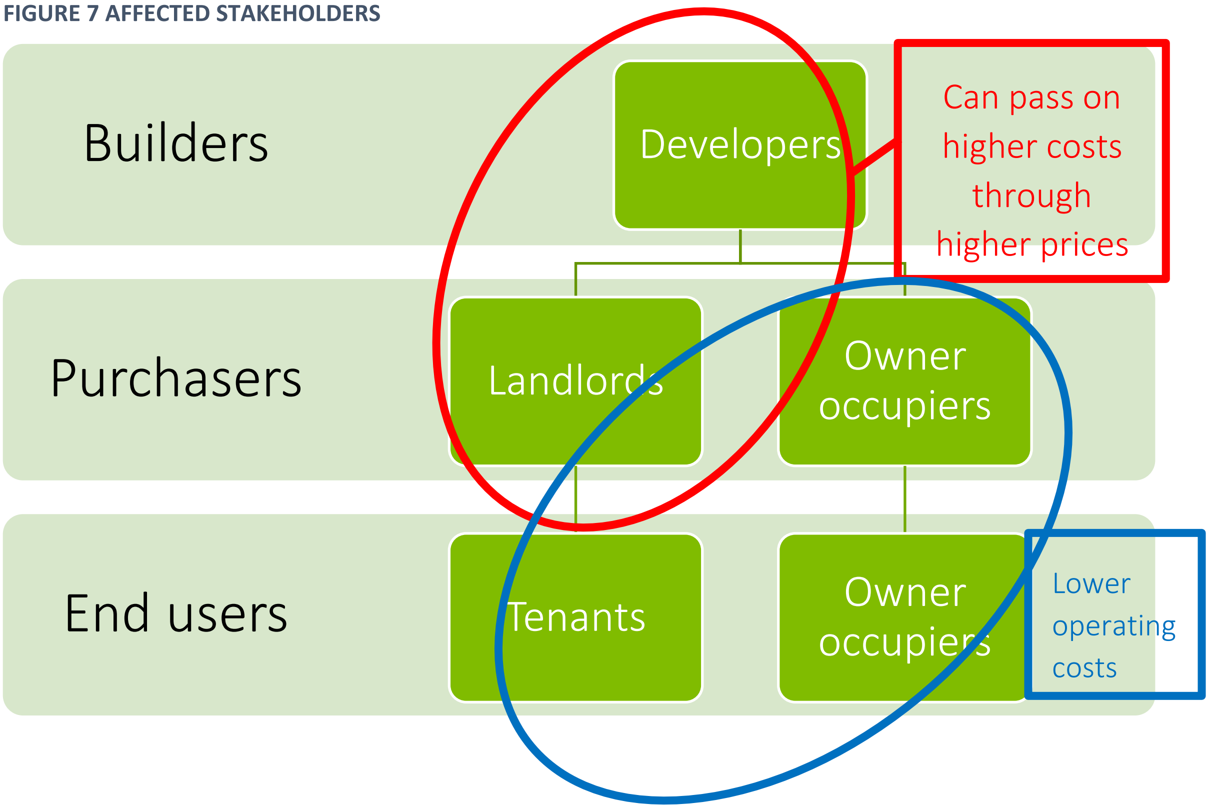
- Focus on cashflows, with greater emphasis on monetary impacts;
- Do not discount future costs and benefits; and
- Are concerned with direct impacts on the main stakeholders (in this case, developers, purchasers and tenants) rather than externalities such as carbon emissions.

While an economic analysis tries to answer the question 'Will this project be good for society as a whole?' a financial analysis tries to answer the question 'Will this project be a financially sensible decision for the people directly using it?'

5.1 Stakeholders in the financial case studies

The focus of the financial case studies is on the impacts to stakeholders who are directly affected by the Amendment requirements, as shown below. Some of these stakeholders will be able to minimise their costs by passing them on other stakeholders.

FIGURE 7 AFFECTED STAKEHOLDERS



When a developer is faced with higher construction costs for a project due to higher building standards, they will generally attempt to pass these on to the purchasers through higher prices. Their ability to do this will depend on levels of supply and demand for comparable properties at the time of sale. If demand for comparable properties is strong, then the developer will simply increase prices to cover their costs (developers are likely to increase prices when demand is strong, regardless of costs). If demand is weak relative to supply, developers may not be able to pass on higher costs and may need to reduce costs elsewhere, accept lower profits or delay/cancel developments if they are not viable. In a balanced market, which is assumed by this analysis, developers can pass on higher costs of construction to purchasers, but without a noticeable reduction in supply.

Likewise, landlords who face higher purchase costs for Amendment compliant buildings will attempt to pass on these higher construction costs through higher rents. In a tight rental market, rents will increase regardless of how much construction costs have increased; if rental vacancies are high, landlords will not be able to pass on their higher costs and may need to reduce rents. In a balanced market, which is assumed by this analysis, landlords will be able to charge higher rents to people living in Amendment-standard buildings due to the benefits of greater comfort, lower energy costs, sustainable transport options and so on.

This Amendment is unlikely to be the pivotal factor in determining the costs of the purchasing or price of rent. Market fluctuations are likely to have much more significant impacts on prices and rents than the impacts of the Amendment.

5.2 Impacts measured for the financial case studies

While many of the costs and benefits included in the economic analysis are relevant for the financial case studies, some will not be. The table below shows the impacts considered in the cost benefit analysis that will or will not be included in the financial case studies.

TABLE 31: IMPACTS INCLUDED OR EXCLUDED FROM THE FINANCIAL CASE STUDIES

Impact	Included	Excluded
Increase in construction costs	✓	
Increase in costs of plant and equipment	✓	
GHG emission reduction from buildings		✓
Reduced energy use	✓	
Avoided health costs of electricity generation		✓
Reduced potable water use	✓	
Reduced embodied carbon		✓
Recovery of organic waste	✓	
Residual value	✓	
Increased active transport (esp cycling)	✓ **	
Increased uptake of EVs	✓ **	
Carbon sequestration		✓
Improved health – neighbourhood effects		✓
Reduction in stormwater treatment costs		✓

Note: ** This will depend on specific actions taken by building users to experience the benefits, namely using the cycling facilities or acquiring an EV.

The benefits that are considered in the financial case studies are those that will provide a cash benefit to either the developers, purchasers or end users of the new buildings; namely, savings in utility costs, recovery of waste and higher residual values.

The main benefit that is excluded is the benefits of reduced carbon emissions, as this is a diffuse benefit that impacts the planet equally. The avoided health costs of electricity generation are also excluded for the same reason – benefits are diffuse and impact thousands of people outside of the building owners and occupiers. All neighbourhood benefits are excluded, as they impact people who do not have any financial interest in the buildings.

5.3 About the case studies

These case studies have been based on four different building typologies, two in ESD councils and two in non-ESD Council areas. These case studies consider the impacts on a range of stakeholders: Developers, owner-builders, owner-occupiers, landlords, residential tenants and business tenants. They consider the unavoidable financial impacts of development, ownership and residents and some of the optional financial impacts. Table 32 shows a summary of the financial case studies considered.

As many of the impacts such as gas and water bill savings are annual, the upfront cost has been annualised by calculating the annual principal and interest mortgage payment required to pay for the higher upfront cost of the building over a 30 year period using a 6.5% interest rate[11].

TABLE 32: SUMMARY OF EXAMPLES

	RES 1	RES 2	RES 4	NON-RES 1
Description	Inner city residential apartment	Regional multi-dwelling residential (2 units on one block)	Medium density suburban apartments	Large suburban office building
Occupation	Owner occupied	Owner hires builder, rents to tenant	Owner occupied	Landlord lets 500sqm space to tenants
Stakeholders	Developer, owners	Owner, builder, tenants	Developer, owners	Developer, purchaser, tenants
ESD status	ESD	Non-ESD	ESD	Non-ESD
LGA	Yarra	Warnambool	Moonee Valley	Boroondara
Benefits outside of utility savings	Secure bike parking – owner cycles to work	EV charging	EV charging	EV charging

5.4 RES 1 case study – Inner city apartment in Yarra

The developer

Major Developments Pty Ltd is a large property developer, specialising in medium to high rise residential apartments. As a result of the Amendment, they now have to spend an additional $9,031 per apartment for their developments. As a result, they put their sale prices for apartments up by the same amount.

[11] 6.5% is the approximate midpoint of interest rates on offer from mortgage comparison sites at the time of writing.

TABLE 33: RES 1 CASE STUDY FINANCIAL IMPACTS – DEVELOPER, PER ANNUM

Impact	Cost	Saving	Net impacts
Likely impacts			
Higher purchase cost (increase in annual mortgage cost)	$9,031		
Increase in sales price	-$9,031		
Net impacts	$0		$0

The owner occupiers

Rajesh and Penny have purchased a three bedroom apartment in Yarra to raise their two children close to their jobs, schools and parks. They paid more for their apartment than Penny's brother did for a similar apartment down the road, finished before the Amendment came in – the Amendment added $9,031 to the cost of building their apartment, which the developer passed onto them in full. This increases the annual payments on their 30 year mortgage by $692, which has a 6.5% interest rate.

The apartment complex is 100% electric, with no gas fitouts. The more energy efficient design and ventilation options means they save $473 on their energy bills each year, even after taking into account the costs of green power. Efficient water design allows them to save $67 per year in water costs, and the organic waste recovery service in their building results in lower body corporate fees of $96 per year.

In addition, the additional bike storage in their building means that Penny starts cycling to work three days a week. Based on a trip of 7km to work, three days a week for 46 weeks per year, at a cost saving of 30.66c/km, she can expect to save $592 per year. The table below summarises the financial costs and benefits of the Amendment for residents of this apartment complex.

TABLE 34: RES 1 CASE STUDY IMPACTS, PER ANNUM

Impact	Cost	Saving	Net impacts
Likely impacts			
Higher purchase cost (increase in annual mortgage cost)	$692		
Energy savings		$473	
Water savings		$67	
Organic waste recovery savings		$96	
Total Likely impacts	$692	$636	-$55
Possible impacts			

Cost savings from cycling		$592	
Health benefits from cycling		Non financial	
Improved air quality from avoiding gas		Non financial	
Total likely + possible impacts			$537

Note: Totals in the table may not equal due to rounding

5.5 RES 2 case study – Small development in Warrnambool

The owner-builder and landlord

Leo and Debbie have decided to demolish their run-down holiday house in the coastal city of Warrnambool and replace it with two homes on one lot, which they plan to rent out. They've arranged for a builder to complete the project for them. Since the Warrnambool Council has no ESD policy in place, the new Amendment have meant that they have had to pay $99,289 more to build the duplex and meet the new standards, around half of which is due to the new green space requirements. As a result, their annual mortgage costs on their principal and interest loan with a 6.5% interest rate are $3,802 more per year. However, they've been able to charge an additional $73 per week in rent, which will covers the increase in mortgage payments.

TABLE 35: RES 2 CASE STUDY FINANCIAL IMPACTS – OWNER-BUILDER & LANDLORD, PER ANNUM

Impact	Cost	Saving	Net impacts
Likely impacts			
Higher purchase cost (increase in annual mortgage cost)	$3,802		
Increase in annual rent	-$3,802		
Net impacts	$0		$0

The residential tenant

Kim is one of Leo and Debbie's tenants. She cares about the environment and has ordered an electric car, but she's struggled to find a rental property that will be affordable to set up a charger for her car. Luckily Leo and Debbie's duplex is set up with a load management system in place to enable electric vehicle charging, which means Kim will save over $100 on setting up an EV charger, and will be able to charge her EV at home rather than having to carefully plan her trips to access public EV charging stations. She also saves $2,939 on energy bills and $357 on water bills each year, as well as $134 due to the better organic waste management in her duplex. In her first year in the duplex, she saves $3530 in total, although this is not enough to cover the higher rent.

TABLE 36: RES 2 CASE STUDY FINANCIAL IMPACTS – RESIDENTIAL TENANT, PER ANNUM

Impact	Cost	Saving	Net impacts
Likely impacts			
Increase in annual rent	$3,802		
Energy savings		$2,939	
Water savings		$357	
Organic waste recovery savings		$134	
Total Likely impacts	**$3,802**	**$3,430**	**-$372**
Possible impacts			
Savings on car charger (once-off)		$100	
Enjoyment of green space		Non financial	
Total likely + possible impacts	**$3,802**	**$3,530**	**-$272**

Note: Totals in the table may not equal due to rounding

Similar findings are likely for townhouse developments up to 10 dwellings per development, ie RES 3 developments. Hip v Hype estimates calculate that retrofitting a townhouse will be closer to $824.

Costing of green infrastructure and small developments

The costings developed by Hip v Hype allow for the green infrastructure requirements for new developments to all be completed by a landscape architect, at a cost of $200/m2 for in ground landscaping, $808/m2 for green roofs and $596/m2 for green walls (in $2020).

This level of technical expertise is essential in high density developments such as RES 1 apartment complexes, where plants for green roofs and walls need to be carefully chosen to protect the structural integrity of the development and ground level green space needs to be designed around underground utilities and carparking.

For low density dwellings, such as 2-4 dwellings on a block of around 1000 square metres, a landscape architect may not be necessary to achieve green space benefits while protecting the structural integrity of the dwellings and surrounding homes. In the RES2 example used by Hip v Hype, the cost of landscaping was estimated at $127,200, a substantial cost for 2-3 dwellings per site. The financial and economic analysis has used these estimates for consistency.

It is highly likely that some small mum and dad developers will choose a cheaper option than this if given the choice. For example, they may seek a landscape designer for advice or hire a landscaping/gardening firm (both of which would be cheaper than a landscape architect) and perhaps supplement some of this assistance with some trips to the plant nursery and a few weekends of their own outdoor garden work.

It is outside the scope of this report to consider how dense a development can be before a landscape architect is required. However, the green space costs of the smaller developments in this report could be substantially reduced from the assumptions used in this report if developers are free to use lower cost options where it is suitable for the development.

5.6 RES 4 case study – Suburban apartment in Moonee Valley

Rory and Shannon are searching for their first apartment. Rory works in the Melbourne CBD while Shannon works at Melbourne Airport. They have chosen Moonee Valley as a convenient location for them both. The new apartment they have chosen is compliant with the Amendment but is more expensive than their friends' apartment, which is 5 years old and located in the same area. The developer passed on an additional cost of $15,959 to the price of their apartment, resulting in an increased mortgage cost of $1,222 per year at a 6.5% interest rate.

In the first year of living in their apartment, they decide to buy an electric vehicle. They were able to do this easily because their apartment complex is already fitted out with EV charging infrastructure. If they had purchased an older apartment, setting it up for an electric vehicle would cost around $2,865 more. (Retrofitting apartments with EV infrastructure is generally more expensive than townhouses or freestanding houses as parking is typically in a common area, involves wiring a multi-storey building, requires body corporate approval and will need to consider other tenants' needs).

In their first year, they find they are saving $66 per year on energy bills, $17 per year in water bills and their body corporate fees are $311 lower per year because of the amount it saves in organic waste recovery. Their higher mortgage cost them $1,222 in their first year in their apartment, but this is offset by saving $2,865 on their EV charging and lower utility payments, so they are ahead by $2,037.

TABLE 37: RES 4 CASE STUDY FINANCIAL IMPACTS, PER ANNUM

Impact	Cost	Saving	Net impacts
Likely impacts			
Higher purchase cost (increase in annual mortgage cost)	$1,222		
Energy savings		$66	
Water savings		$17	
Organic waste recovery savings		$311	
Total Likely impacts	**$1,222**	**$394**	**-$828**
Possible impacts			
Savings on car charger (one off)		$2,865	
Enjoyment of green space		Non financial	
Total likely + possible impacts	**$1,222**	**$3,259**	**$2,037**

Note: Totals in the table may not equal due to rounding

5.7 NON-RES 1 case study – Office building in Boroondara

The landlord

Lilly, a commercial landlord, was looking for commercial real estate to buy in Hawthorn. They had two options - a new building compliant with the Amendment and an older office building. Although the older building had a lower upfront cost, Lilly conducted thorough research and found that the new Amendment compliant building would provide a better value proposition. The new 7,980 sqm building had an added construction cost of $827,517, which will increase mortgage costs per year by $63,369.

Overall, the building saves $11,972 on gas, $7,497 on water and $5,592 on organic waste recovery; but spends an additional $16,437 on electricity, including the costs of carbon neutral power. And so, the building's would save a total of $8,624 from utilities. If the Lilly shopped around to find an electricity provider that did not charge for green power, the electricity bill would only increase by $6,757. Finding a provider with that does not charge a premium for carbon neutral power would mean she saves a total of $18,304 on her building's energy, water and waste costs compared to a non-Amendment building.

While the new building has higher upfront and ongoing costs, the extra EV charging stations, shading to the sunny sides of the building and additional green space were not available in other older office buildings in Hawthorn.

Lilly was able to attract a wider variety of tenants for the office spaces and at a rent premium. Businesses that have net zero commitments or environmentally consensus clients were drawn to the carbon-neutral offices and climate focused amenities.

TABLE 38: NON-RES 1 CASE STUDY FINANCIAL IMPACTS - ENERGY SAVINGS FOR ENTIRE BUILDING, PER ANNUM

Impact	Regular energy provider	Energy provider does not charge premium
Likely impacts		
Higher purchase cost (increase in annual mortgage cost)	$63,369	$63,369
Electricity savings	-$16,437	-$6,757
Gas savings	$11,972	$11,972
Water savings	$7,497	$7,497
Organic waste recovery savings	$5,592	$5,592
Green energy cost		-$9,680
Total savings on utilities bill	**$8,624**	**$18,304***

Note: Totals in the table may not equal due to rounding
* Excluding green energy cost

The commercial tenant

Bus Stop Marketing (BSM) had been looking for a 500sqm office space around Boroondara. They have committed to being a carbon neutral business by 2025, and an Amendment compliant building makes it easier for them to achieve that. Lilly charges BSM $3,971 more in rent per year than they would pay for a similar sized office space that wasn't Amendment compliant, which makes their office operations carbon neutral. While their energy costs increased by $280 per annum, BSM save $470 in water bills and $350 in organic waste recovery savings each year. BSM find their commitment to carbon neutrality is attracting new customers who aim to be ethical purchasers.

TABLE 39: NON-RES 1 CASE STUDY FINANCIAL IMPACTS – COMMERCIAL TENANT, PER ANNUM

Impact	Cost	Saving	Net impacts
Likely impacts			
Higher purchase cost (increase in annual mortgage cost)	$3,971		
Energy savings		-$280	

Water savings		$470	
Organic waste recovery savings		$350	
Total Likely impacts	$3,971	$540	-$3,430
Possible impacts			
Additional EV parking for immediate use		Not quantified	
Enjoyment of green space		Non financial	
Total likely + possible impacts	$3,971	$540	-$3,430

Note: Totals in the table may not equal due to rounding

5.8 Summary of case study findings

It is expected that developers and landlords will be able to pass on their increased costs from the Amendment to their purchasers/tenants. The proposed Amendment will have the greatest impact on people who purchase or occupy all or part of a new building constructed after the Amendment's implementation. These individuals will face higher upfront purchase costs and possibly higher rents, as a result of the higher upfront construction costs. In the short term, this may pose challenges for small businesses, businesses who require a large floorspace or low income households in finding accommodation.

While over time these businesses and households will receive some benefits from lower energy costs, easier active transport, improved wellbeing and so forth, struggling households and businesses may not personally experience benefits that outweigh the costs, as a major source of benefits of this Amendment is the reduction in carbon emissions. While reducing carbon emissions is indeed beneficial to the world as a whole, the collective nature of the benefits of emissions reduction means that a disadvantaged household who faces higher rents as a result of the Amendment will not personally receive a financial benefit from emissions reduction.

The Hip v Hype data used in this analysis is only able to support a very high level financial investigation. It does not provide the total costs of constructing a building under the base case or the project case, only the *increase* in construction costs; likewise it does not estimate total utility bills, only the *increase or decrease* in utility costs. Their methodology took existing building designs and estimated how much extra an Amendment standard building would cost over the base case. It does not include the savings inherent in innovation in design and construction methods; ie over time designers and developers will adjust their standard offerings and built form designs to reduce the cost of meeting the new standards.

Caveats to the financial investigation

The case study approach to illustrating the financial impacts of the Amendment will not be representative of all projects, as there will be significant variations in how people will use the buildings, differences in costs and savings of different fitouts and features, and potential improvements in efficiency of designs over time.

The main goal of the Amendment is to reduce carbon emissions. While Victorians will bear the higher costs of the Amendment standards, the planet also benefits from the reduced greenhouse gas emissions due to reduced energy use and individuals switching from ICE vehicles to EVs. The total value of carbon abatement expected from the Amendment is $4 billion, and the reduced emissions from EV uptake is valued at around $400 million. These benefits accrue to not only residents in these neighbourhoods, but to various stakeholders including all citizens globally as well as local, state and federal governments (for example, the reduction in ICE vehicle registrations contributes to governments' emissions reduction targets).

There are also several benefits in the financial analysis that may result in individual savings that are not quantified. Improved health from green space and better indoor temperature control is likely to create financial savings for *some* households, but it will not be possible to tease out the financial benefits that accrue to specific households. The analysis also does not quantify the energy savings from ventilation and shading, to avoid double counting with operational energy benefits.

Finally, the actual returns to developers, landlords, owner occupiers and tenants are heavily dependent on what the market will bear at the time, rather than the cost of the initial build of the dwelling.

6. Conclusions

This analysis shows that overall, the proposed impact of the Amendment is expected to be strongly positive, and the results are robust to sensitivity testing. The CBA delivers a BCR of 1.48 with a 7% discount rate. This is comfortably high, with many infrastructure projects typically returning a BCR between 1 and 2.

The benefits are primarily driven by returns relating to operational energy. It is a well known fact that embodied carbon in the construction of buildings and the operation of houses and commercial buildings are important contributors to Australia's emissions. The Amendment paves the way for better building practices, reduced consumption of energy and a transition to renewables energy sources.

The second highest category, though at substantial distance from the first, comprises green infrastructure benefits. Carbon sequestration and improved health benefits were monetised as part of the analysis. To avoid any risk of double counting, other key benefits such as neighbourhood cooling and avoided heat related illnesses were not included. Heatwaves kill more people in Australia than any other natural hazard, including bushfires, cyclones and floods[12]. The extent of the Amendment's influence on preventing heat related illnesses is unclear, but likely substantial.

When considering potential distributional impacts, the costs of the Amendment are borne by the end users of the buildings, but some of the benefits are diffuse, affecting neighbourhoods and even the entire world through the reduction in carbon emissions. This means that some disadvantaged households or small businesses may find the costs to their personal finances of the Amendment may be greater than the benefits they personally experience.

The nature of the calculation of benefits in this project, in particular, the use of specific buildings as hypothetical examples representing the breadth of Victorian building development, may result in the costs of some of the amendments being overstated and some of the benefits being understated. Two key examples are:

- Estimation of benefits for the Amendment considered the benefits of energy saving in building design, but the additional benefits of shading, ventilation and green infrastructure on the resident's power bills were not quantified to avoid double counting with other building design standards. As a result, impacts on comfort, health and power bills may be underestimated.
- Estimation of the costs of green infrastructure for all projects were based on a landscape architect developing the green infrastructure. While this level of expertise will be necessary for medium to high density developments, it may not be necessary for some lower density developments. The cost of the Amendment to lower density dwellings could be substantially reduced from the estimates used in these calculations if the green space was created by a landscape designer, gardener or even the property owner.

[12] Coates L, Haynes K, O'Brien J, McAnerney J, de Oliveira F D 2014, "Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844-2010", Environmental Science and Policy, vol. 42, p. 33-44.

There is substantial evidence that shows property values in green environments gain a premium as they are more desirable places to live. The same is true for places with better thermal comfort. These premiums may help offset some of the additional costs to property owners.

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8. Appendix 1: SGS's Cost benefit analysis framework

The aim of the CBA is to assess the costs and benefits of the Amendment and to determine the overall impact on net community welfare. This section gives a general overview of CBA methodology.

8.1 CBA methodology

A CBA assesses the merit of investing in a project from a broad community perspective. That is, a CBA contrasts an initiative's economic, social, and environmental benefits with its costs. Ultimately the purpose of this form of appraisal is to determine whether the initiative under examination delivers a net benefit to the subject community; in this case, all Victorians.

The relative scale of costs and benefits are illustrated via the benefit cost ratio (BCR). If the BCR is greater than one, the project is considered worth pursuing from a societal welfare or 'economic efficiency' perspective, regardless of who pays and who benefits.

The CBA must address the full spectrum of environmental, social and business impacts of the Amendment. Positive and negative effects are quantified and monetised (expressed in dollar terms) as far as possible and then compared to arrive at a conclusion as to whether the proposal is likely to make the community better off or worse off in net terms compared with persevering with business-as-usual (BAU) conditions.

The principal steps in the CBA method include:

1. Differentiating between the outcomes under a 'business as usual' or 'base case' scenario and those arising with the initiative in question, or the 'project case'.
2. Identifying the economic, social, and environmental costs and benefits that might arise in moving from the base case to the project case.
3. Quantifying and monetising these costs and benefits, where possible, over a suitable project evaluation period (in this case, 40 years).
4. Generating measures of net community impact using discounted cash flow techniques over the duration of the initiative in question. This requires expression of future costs and benefits in present value terms using a discount rate that reflects the opportunity costs of resources diverted to the implementation of the project case.
5. Supplementing this quantitative analysis with a description of costs and benefits that cannot be readily quantified and monetised.

All impacts of the proposed intervention must be taken into account, regardless of whether or not they are priced and traded in the market. The unpriced 'externalities' are attributed a monetised value using various techniques in accordance with CBA guidelines.

8.2 Marginal costs and benefits

A CBA aims to establish the merit of a project by measuring and comparing the marginal costs and benefits. Marginal costs and benefits are the additional costs and additional benefits that arise in the project case relative to the base case. Costs and benefits that occur in both cases are not considered because they do not reflect any difference between the two.

8.3 Incremental, present value, lifecycle assessment

As per the conventions of financial and economic appraisal, CBA is conducted on an incremental or 'marginal' basis. That is, the project outcomes are tested in comparison to the outcomes that would be generated under a business-as-usual scenario.

Moreover, the CBA framework accounts for the time value of money, which is an implicit judgement that it is desirable for a benefit to occur sooner, rather than later. Accordingly, this cost benefit analysis has been prepared in real dollar terms, with future costs and benefits discounted back to current day dollars using a consistent real discount rate. In essence, this means the costs and benefits which accrue earlier in the project are given more weight than those in the more distant future.

8.4 Limitations

CBA provides a useful framework to consider the consequences of a proposed project, however its application has its limitations. There are instances in which the results of CBA should not govern ultimate moral judgement. Often these encompass projects and initiatives which have consequences for those things that are specially valued as a society, such as life, health, safety, and human rights.

As useful as this framework is, not all costs and benefits are admissible in a CBA. This is not because they are beyond the reach of economics, but rather that they may be deemed to be unconscionable policy propositions. CBA is therefore only suitable for policy choices which are within the spectrum of acceptability based on shared values.

9. Appendix 2: Benefits from Frontier Economics analysis

Below we have inserted the method outlined by Frontier for monetising the quantifiable benefits in their *Sustainability Planning Scheme Amendment – Cost-Benefit Analysis* report.

2.4.2 Benefit data

Quantified benefits

To value benefits, we have drawn on robust valuation benchmarks as outlined in **Table 3**, with further information provided at Appendix B.

Table 3: CBA valuation benchmarks

Benefit Category	Valuation Approach
Greenhouse gas (GHG) emission reduction	Our valuation includes the following steps: ▪ applying the estimated reduction in gas and electricity consumption (obtained from ESD technical workstream) ▪ forecasting emission intensity factors for Victoria during the evaluation period (see Appendix B) ▪ converting reduced gas and electricity consumption into reduced GHG emissions using forecast emission intensity factors ▪ multiplying the reduced emissions by a social cost of carbon ($75/tonne CO2-e) – Frontier Economics estimate of the economic costs, or damages, of emitting one additional tonne of GHG into the atmosphere.
Reduced energy use (electricity & gas)	We have estimated the resource cost savings associated with reduced electricity and gas consumption, including reduced network and wholesale costs: ▪ For electricity network costs, we have based our estimates on published values for the long-run marginal cost (LRMC) from Victorian electricity network distribution businesses ($0.01/kWh).

	▪ For deferred gas network costs, we have adopted an estimate of $4.50/GJ based on a recent Consultation RIS undertaken by ACIL Allen ▪ For electricity wholesale costs, we have assumed a flat $70/MWh (Frontier Economics estimate/assumption) ▪ For gas wholesale costs, we have used price forecasts from the Australian Energy Market Operator's 2022 Integrated System Plan (based on new entrant combined cycle gas turbine generator prices) (see Appendix B) See Appendix B for further discussion on why we have not applied a retail
Avoided health costs of electricity generation	Electricity generation produces air pollution containing particulate matter, nitrogen oxides, sulphur dioxide, as well as other emissions. These can cause health problems such as respiratory illness and can also affect local economies. We estimated the health benefits of avoided coal and gas-fired electricity at $1.78/MWh. See Appendix B for information.
Reduced potable water use	Our valuation approach involves: ▪ applying the estimated reduction in potable water use (in megalitres) (obtained from ESD technical workstream) ▪ multiplying the reduction in potable water use by the estimated LRMC of water supply based on the value advised by Melbourne Water ($2,450/ML).
Reduced embodied carbon	Estimates of reduced embodied carbon obtained from the ESD technical workstream were multiplied by the social cost of carbon discussed above.
Reduced waste to landfill/value of recovered materials	Estimates of reduced construction and demolition waste to landfill (tonnes) were multiplied by the full economic cost of landfill and the net value of recovered materials. This approach provides an estimate of the avoided cost of landfill and value of recovered materials of $125/tonne. See Appendix B for information.
Recovery of organic waste	Estimates of organic waste recovered, obtained from the ESD technical workstream, were multiplied by an average value added for organic waste. To estimate the average value added for organic waste we used data from Australian Organics Recycling Association's publication 'Australian Organics Recycling Industry Capacity Assessment: 2020-21'. This approach provides an

	estimate of the value added by additional organic waste recovered of $93/tonne.
Residual value	Some assets have a useful life that is greater than the analysis period of the CBA. The residual value is the estimated value of assets at the end of the appraisal period, representing the expected value in continuing use. We calculate residual value as the present value of future benefits.

Appendix B. More information on benefit valuation

This appendix providers further information on our approach to valuing benefits in the CBA.

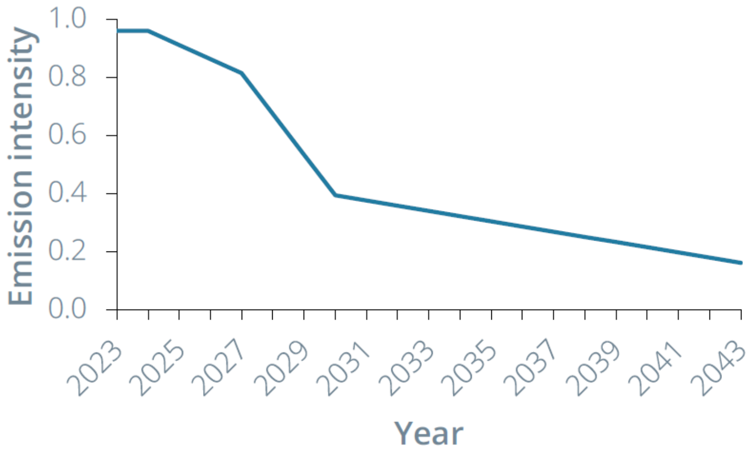
Avoided GHG emissions

Forecast emission intensity

As discussed in section 2.4, to estimate the value of avoided GHG emissions we have applied a forecast of the emission intensity of the Victorian electricity grid. The emission intensity of the grid is expected to fall over time as more renewable energy enters the market.

We have derived our forecasts from the Victorian Government's Victorian Energy Upgrades (VEU) program. The VEU published forecast 10-year average emission intensity estimates. For example, the 10-year average emission intensity estimate for 2025 is 0.393 tonnes CO2-e/MWh. We have assumed this represents a reasonable point estimate for 2030. From 2030, we have assumed emission intensity tends towards zero in 2050 in line with the net zero commitment. Our forecast emission intensity is summarised in **Figure 5** below.

Figure 5: Forecast emission intensity (tCO2-e/MWh)



Source: Frontier Economics, based on Victorian Government commitments.

Reduction in energy use

In valuing reduced energy consumption, it is sometimes considered that the value should be based on the reduction in retail electricity bills experienced by customers as a result of reduced consumption. However, this conflates economic benefits with distributional impacts. For instance, because many retail costs of energy are fixed (i.e. don't vary with the volume of energy consumed), reducing these costs for some customers results in them being redistributed to other customers.

Our approach to valuing benefits from reduced energy use is based on the estimated resource cost savings for society. These include:

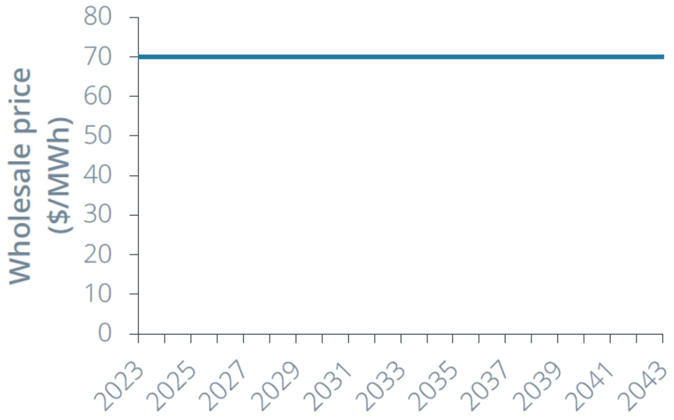
- variable costs avoided (estimated through wholesale market prices) and
- reduced capacity needed in the long run for electricity and gas network infrastructure.

Our approach is in line with guidance provided to the Australian Government for residential energy efficiency regulatory impact studies.

Wholesale market prices

We have projected the wholesale electricity price will remain stable at $70/MWh ($0.07/kWh) as summarised **Figure 6**.

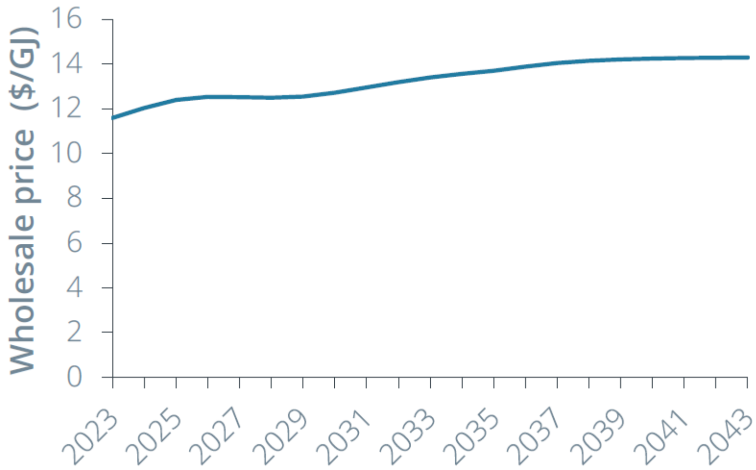
Figure 6: Wholesale electricity price projection ($/MWh)



Source: Frontier Economics

Our forecast wholesale gas price is shown in **Figure 7** below. Our forecast derives from the Australian Energy Market Operators (AEMO's) 2022 Integrated System Plan (ISP). The ISP includes a modelling assumptions workbook with generator fuel prices. We have applied prices for new combined cycle gas turbine (CCGT) generation in Victoria, as individual generator prices may reflect some view on their legacy contracts. We consider that CCGT is closer to the system profile for gas demand, compared to open cycle gas turbine (OCGT).

Figure 7: Wholesale gas price projections ($/GJ)



Source: AEMO, 2022 Integrated System Plan – Modelling assumptions workbook

Network costs

A reduction in energy use means that over the longer run investment in new generation capacity may be deferred or avoided. The change in costs as a consequence of small changes in electricity or gas consumption are known as the long run marginal costs (LRMC). LRMC is a forward-looking concept and amounts to a measure of the additional cost incurred as a result of a relatively small increase in output, assuming all factors of production are able to be varied.

Estimates of LRMC are available for electricity network businesses in Victoria as part of their Tariff Structure Statements. We converted residential LRMC ($/kilowatt/pa) into a single rate LRMC by dividing by the number of hours in a year. This produced an estimate of around $0.01/kWh.

For deferred gas network costs, we have adopted an estimate of $4.50/GJ based on a recent Consultation RIS undertaken by ACIL Allen. This estimate is based on forecast capital expenditure on augmentations in the most recent revenue determinations for each gas distributor and the forecast growth in demand from new connections.

Avoided health costs of electricity generation

Electricity generation produces air pollution containing particulate matter, nitrogen oxides, sulphur dioxide, as well as other emissions. These can cause health problems such as respiratory illness and can also affect local economies.

We estimated the health benefits of reduced coal and gas-fired electricity using the studies referred to by ACIL Allen in the Consultation RIS for the National Construction Code 2022. This resulted in avoided health damage costs of:

- $2.58/MWh for coal-fired generation
- $0.93/MWh for gas generation

We applied a weighted average of these values reflecting the share of coal (67.7%) and gas fired (4.5%) electricity generation in Victoria in 2020 ($1.78/MWh), declining over time as the rate as emission intensity discussed above.

Reduction in potable water use

We have valued reductions in potable water use brought about by elevated ESD standards based on LRMC. LRMC represents the cost of changing the capacity of a water supply system by building a permanent new supply source (such as a dam or a desalination plant). Water utilities use LRMC to decide if a water conservation activity is cheaper or more expensive than the cost of building a permanent augmentation to the water supply system. The LRMC applied in our analysis ($2,450/ML) is based on advice from Melbourne Water.

Avoided landfill / increased recycling

Estimates of reduced construction and demolition waste to landfill (tonnes) were multiplied by the full economic cost of landfill. To estimate the economic cost of landfill we:

- Reviewed published landfill gate fees for commercial and industrial waste and determined an indicative fee of $250/tonne (we placed more weight on metro rates given this is where most volume would be generated)
- Subtracted the current waste levy for industrial waste ($100/tonne) – average of metro and rural representing a financial transfer
- Added an estimate of externality costs of landfill representing visual disamenity ($1/tonne)
- Subtracted an estimated recovery and processing cost for mixed concrete $43/tonne (including transport)
- Added an estimated value of recovered materials for mixed concrete of $18/tonne)

This approach provides an estimate of the avoided cost of landfill and value of recovered materials of $125/tonne.

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