FINAL REPORT

Increasing the stringency of the commercial building energy efficiency provisions in the 2025 National Construction Code

Consultation Regulation Impact Statement

Prepared for
Australian Building Codes Board

April 2024

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Abbreviations

AAA	Australian Automobile Association
ABCB	Australian Building Codes Board
ACCC	Australian Competition and Consumer Commission
ACCU	Australian carbon credit unit
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ASBEC	Australian Sustainable Built Environment Council
BCA	Building Code of Australia. BCA includes the National Construction Code (NCC) Volume One (primarily applies to Class 2 to 9 buildings and structures) and Volume Two (primarily apples to Class 1 buildings and Class 10 structures)
BCR	Benefit-cost ratio
BEEC	Building Energy Efficiency Certificate
BEET	Building Energy Efficiency Taskgroup
CBA	Cost-benefit analysis
CBD	Commercial Building Disclosure Program
CIE	The Centre for International Economics
CO_2-e	Carbon dioxide equivalent
COAG	The Council of Australian Governments
COP	Coefficient of performance
CRIS	Consultation regulation impact statement
CZ	Climate Zone
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DTS	Deemed-to-satisfy
DUOS	distribution use of system
ESG	Environmental, Social and Governance
EV	electric vehicle

FCAI	Federal Chamber of Automotive Industries
FY	financial year (July to June)
GBCA	Green Building Council of Australia
GFA	Gross Floor Area
GHG	Greenhouse gas
GSP	Gross state product
GST	Goods and services tax
GVA	Gross value added
HVAC	Heating, ventilation, and air conditioning
ICE	internal combustion engine
IEA	International Energy Agency
IEQ	indoor environmental quality
IPEEC	International Partnership for Energy Efficiency Cooperation
ISP	Integrated System Plan
JSA	jurisdictional scheme amounts
kWh	kilowatt hour
kWr	kilowatts of refrigeration capacity where kW relates to kilowatts of electrical power
LED	Light emitting diode, a semiconductor device that converts electricity into light
LGC	Large-scale generation certificates
LRET	Large-scale Renewable Energy Target
LRMC	Long run marginal cost
MEPS	Minimum Energy Performance Standards
NABERS	National Australian Built Environment Rating System
NCC	National Construction Code. The NCC is comprised of the Building Code of Australia (BCA), Volume One and Two; and the Plumbing Code of Australia (PCA), Volume Three.
NEM	National Electricity Market
NEPS	National Energy Performance Strategy
NLA	Net lettable area
NPV	Net present value

NUOS	network use of system
OIA	Office of Impact Analysis
OCC	Opportunity cost of capital
PACS	packaged air-conditioning systems
PC	Productivity Commission
PCD	Public Comment Draft (of NCC 2025)
PJ	petajoule
PV	photovoltaics
RCP	Representative Concentration Pathway
RET	Renewable Energy Target
RIS	Regulation impact statement
R-Value	The R-Value is a measure of thermal resistance, or ability of heat to transfer from hot to cold, through materials (such as insulation) and assemblies of materials (such as walls and floors). The higher the R-Value, the more a material prevents heat transfer.
SA	Sensitivity analysis
SCC	Social cost of carbon
sDA	Spatial Daylight Autonomy – a yearly metric that describes the percentage of space that receives sufficient daylight.
SEPP	NSW Sustainable Buildings State Environmental Planning Policy
SHGC	Solar Heat Gain Coefficient – how readily heat from direct sunlight (solar radiation) flows through a window system. Value between 0 and 1. The lower a window's SHGC, the less solar heat it transmits.
SRI	Solar Reflectance Index
SPR	Strategy.Policy.Research
SRET	Small-scale Renewable Energy Target
SRMC	Short run marginal cost
STC	small-scale technology certificate
TLA	Tenancy Lighting Assessment
ToU	time of use
TRG	Technical Reference Group
TUOS	transmission use of system
UNFCCC	United Nations Framework Convention on Climate Change

USEPA	United States Environmental Protection Agency
U-Value	The U-Value is the overall heat transfer coefficient that describes how well a building element conducts heat or the rate of transfer of heat (in watts) through one square metre of a structure divided by the difference in temperature across the structure. It measures how readily a window system conducts heat. It is a measure of the rate of non-solar heat loss or gain through it. The lower a U-Value, the better. U-Value is the reciprocal of R-Value.
VM	Verification Method
VRF	variable refrigerant flow system
WACC	Weighted average cost of capital
WWR	Window to wall ratio – calculated based on the window area divided by the total façade area exposed to conditioned air, which includes the plenum space in the same orientation.

Executive summary

Energy efficiency is an important focus of the Australian and state and territory governments' strategies to improve energy productivity and reduce greenhouse gas (GHG) emissions.

The Australian Building Codes Board (ABCB) is leading work to scope potential changes for commercial buildings in the 2025 edition of the National Construction Code (NCC). As part of the NCC 2025 development process, the ABCB has engaged the Centre for International Economics (CIE) to prepare a Consultation Regulation Impact Statement (CRIS). The CRIS assesses the costs and benefits of the proposed changes to the commercial building energy efficiency requirements in NCC 2025.

The CRIS aims to assist in public consultation by providing a basis for feedback on the likely impacts from the proposed commercial building energy efficiency changes to NCC 2025. Following this process, the information in this CRIS will be updated by incorporating relevant information and data collected throughout the public consultation process. This will lead to a final Decision Regulation Impact Statement (DRIS) which will support decision making on the NCC 2025 changes.

The commercial buildings covered in this CRIS are defined as common areas of Class 2 (apartments), Class 3 buildings (hotels and other commercial accommodation facilities), Class 5 buildings (offices), Class 6 (retail buildings, such as shops, restaurants and cafes), Class 7 buildings (carparks and warehouses), Class 8 buildings (factories) and Class 9 buildings (health care, education, sporting and aged care buildings).

Statement of the problem

The rationale for minimum energy efficiency standards is based on the proposition that industry would not make socially optimal energy efficiency decisions in commercial buildings without regulation, due to market failures and behavioural anomalies. These include the following:

- Negative externalities associated with energy consumption — energy consumption can impose costs on the community that are not fully reflected in energy prices. This includes costs associated with GHG emissions. As many energy users may not take into account these 'negative externalities' in their decisions, they may under-invest in energy efficiency.
- Other market failures and behavioural anomalies — policy measures to improve energy efficiency can arguably deliver net private benefits through bill savings that outweigh the associated capital costs. This implies there are energy efficiency

opportunities that are privately cost effective that industry nevertheless fails to adopt. This is often referred as the 'energy efficiency paradox'.[1]

A suite of policies has been introduced by government to address these market failures and behavioural anomalies. With aligned objectives in improving energy performance, there is a scope for an increase in the energy efficiency requirements in the NCC for commercial buildings on the basis that:

- The national emission targets have been legislated. The Australian Government is committed to net zero emissions by 2050. Consistent with the net-zero emission agendas, the Australian Government is developing sectoral decarbonisation plans. In particular, the sectors of electricity and energy, the built environment, and transport are of high relevance to the NCC.
- High-level strategies set out roadmaps for achieving the net zero target and other related objectives. They include:
  - National Energy Performance Strategy – provides a long-term framework for demand-side action and encapsulates management of energy demand.
  - Trajectory for Low Energy buildings – specifically proposes incremental changes to the NCC to reduce operational energy use and associated GHG emissions of residential and commercial buildings from 2022.
  - National Electric Vehicle Strategy – of most relevance to the NCC is the intention to make it easy to charge an electric vehicle (EV) across Australia. This can be supported by the NCC where charging capabilities in commercial buildings provide an additional charging option, including for households that do not have access to charging at home.
- Specific policies aim to improve energy efficiency and electrification in commercial buildings as well as EV uptakes. They include:
  - NABERS – referenced in the NCC as an energy efficiency Verification Method.
  - ACT and Victoria electrification schemes and bans of gas connection – lay out changes to planning and building regulation.
  - An array of EV uptake incentives and fuel efficiency standards – these will be supported by the NCC's EV charging provisions.

Objectives and options

The more recent energy efficiency changes to the NCC were initiated by the National Energy Productivity Plan in 2015, which was then followed by the *Trajectory for Low Energy Buildings* (the Trajectory) in 2019. The Trajectory aims to set a trajectory towards zero energy (and carbon) ready buildings. With GHG emission reduction targets legislated in 2022, Energy Ministers agreed to support the changes (shown as

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1 Gerarden, T.D., Newell, R.G. and Stavins, R.N. 2015, *Assessing the Energy Efficiency Gap*, Duke University Energy Initiative and Harvard Environmental Economics Program, January 2015, p. 1.

Stringency Level 3 below) that achieve a low energy, net zero carbon building sector by 2050.

The objective of the NCC 2025 energy efficiency project is to support the Trajectory. Specifically, the changes are to:[2]

- reduce GHG emissions,
- reduce commercial building running costs,
- make commercial buildings more resilient to heatwaves, and
- assist with the decarbonisation of the electricity grid.

To achieve these objectives, three options have been developed in relation to the stringency levels of the energy efficiency requirements for commercial buildings (table 1):

1. Stringency Level 1: Cost-effective energy efficiency without mandated on-site photovoltaics (PV)

   Stringency Level 1 includes proposed energy efficiency provisions for improving the performance of the building envelop and equipment.
2. Stringency Level 2: Cost-effective energy efficiency with mandated on-site PV

   Stringency Level 2 introduces additional mandated on-site PV requirements to Stringency Level 1.
3. Stringency Level 3: Least cost zero carbon ready buildings

   Stringency Level 3 covers least cost zero carbon provisions that achieve net zero GHG emission ready buildings (for when the grid decarbonises) with respect to regulated energy (i.e. the energy use of equipment regulated through the NCC). This option extends Stringency Level 2 to provide full electrification readiness and to require additional PV to offset emissions from gas appliances compared with an all-electric equivalent. This means that under Stringency Level 3, a building's operational carbon emissions will be no higher than an equivalent all-electric building.

1 Options of proposed changes

Option	Scope
Option 1	Stringency Level 1 + EV charging facility requirements
Option 2	Stringency Level 2 + EV charging facility requirements
Option 3	Stringency Level 3 + EV charging facility requirements

Source: ABCB

The proposed provisions will also be fuel and technology neutral under all options. This means the proposed NCC changes, at each stringency level, will allow the use of suitable electric- and gas-powered equipment, provided the required overall level of efficiency and emissions is achieved.

2 ABCB 2022, *NCC 2025 energy efficiency project: Rationale and Scope*, 2022, p.1

For each of the stringency levels, there is the same mandatory requirement for EV charging facilities. The EV requirements are proposed to accommodate the increasing uptake of EV in the future, which will reduce GHG emissions along with decarbonisation of the grid. The requirements will also provide convenience for EV owners.

These three options are evaluated against the reference option (status quo), that is NCC 2022 compliant buildings.

Key findings

All three options under consideration are estimated to deliver significant net benefits (relative to current NCC 2022 requirements).

Table 2 summarises the cost-benefit analysis (CBA) results for each of the three options (compared to current practice under the current NCC 2022 provisions). All costs and benefits are expressed in net present value terms (using a discount rate of 5 per cent) over the life (assumed to be 50 years) of all commercial buildings to be constructed over the 10-year period from 2025 to 2034 (please refer to chapter 4 for detailed CBA parameters). Benefit-cost ratios are not reported in the table because there are capital cost savings under Stringency Level 1.

2 Estimated impacts of proposed options

Impacts	Option 1 ($ million)	Option 2 ($ million)	Option 3 ($ million)
Building energy impacts			
Avoided electricity network capacity costs	1,168.76	1,835.93	1,811.55
Avoided electricity wholesale costs	2,079.18	3,702.37	3,644.44
Avoided electricity network usage costs	1,757.91	3,539.61	3,515.61
Avoided electricity retail costs	750.88	1,361.69	1,345.74
Electricity exported to grid	71.94	446.50	446.81
Avoided gas costs	-16.95	-16.95	61.04
Avoided GHG emissions - electricity	1,799.92	3,420.84	3,394.01
Avoided GHG emission – exported electricity	130.08	778.40	779.29
Avoided GHG emissions - gas	-33.28	-33.28	119.63
Capital costs	743.02	-2 335.34	-2 746.26
Total building energy impacts	**8,451.44**	**12,699.77**	**12,371.86**
Mandatory EV charging			
Improved access to destination charging	1,560.62	1,560.62	1,560.62
Mitigation of climate change	84.06	84.06	84.06
Mitigation of air pollution	12.10	12.10	12.10
EV charging equipment installation and maintenance	-3,396.79	-3,396.79	-3,396.79
Total EV charging	**-1,740.01**	**-1,740.01**	**-1,740.01**
Total	**6,711.43**	**10,959.76**	**10,631.85**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10-year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Key findings are as follows:

- Option 1 is estimated to deliver net benefits of around **$6.7 billion** in net present value terms:
  - The proposed changes to the minimum energy efficiency standards for building envelope and equipment are estimated to deliver net benefits of around $8.5 billion.
  - These benefits are partly offset by the EV charging requirements, which are estimated to impose a net cost of around $1.7 billion (this applies across all options).
- Option 2 is estimated to deliver the highest net benefits of all the options — around **$11 billion** in net present value terms.
- The estimated impacts of Option 3 are slightly lower than Option 2 at around **$10.6 billion**.

Sensitivity analyses was conducted to test key assumptions. The key findings from the sensitivity analysis are as follows:

- Under all alternative assumptions, all three stringency levels are estimated to deliver a net benefit relative to NCC 2022. This suggests that the case for change is relatively robust.
- Under most alternative assumptions, Stringency Level 2 is estimated to deliver the highest net benefits, consistent with the central case. The key exceptions are as follows:
  - Under all scenarios involving future electrification, net benefits are higher for Stringency Level 3.
  - Under the scenario where all buildings choose the 'dual fuel offset' option[3], the net benefits are higher for Stringency Level 3[4].
- The magnitude of the CBA results is most sensitive to:
  - The choice of discount rate.
  - The realisation rate — there is some evidence that modelled energy efficiency benefits are not (on average) fully realised, although there is no reliable evidence on the extent to which actual energy savings fall short of modelled outcomes. This suggests that the true net benefits may be somewhat lower than has been estimated. That said, all stringencies are estimated to deliver a net benefit even under a pessimistic scenario where only 50 per cent of the benefits are realised.

The CRIS model covers the 10-year period between 2025 to 2034 (a standard approach to assess regulatory impacts). However, it is worth noting that there might be a transitional period considered when implementing the NCC. Also, given the

3 Note that the term "offset" is used in this report only relates to on-site renewables.

4 Under the 'dual fuel offset' option, a building can use both gas and electricity but will require additional on-site renewables to balance emissions from gas appliances compared with an all-electric equivalent. Under this stringency, the building's operational carbon emissions should be no higher than an equivalent all-electric building.

time required for building approval and construction, it is unlikely any NCC 2025-compliant buildings will be operational from 2025.

The CRIS uses AEMO's Step Change scenario for energy price forecasts, aligning with the recommendations in the paper "*Economic parameters for technical work (NCC)*"[5]. It is important to note, however, that future energy prices are anticipated to exhibit volatility, with a potential upward trajectory in near term. This implies that the estimated energy cost savings may be conservative due to the dynamic nature of future pricing trends.
Similarly, the assumed GHG emissions factors for future electricity consumption might deviate from the pace of grid decarbonisation. This potential discrepancy yields mixed effects. If decarbonisation of electricity supply from the grid were to happen more slowly than assumed, the reduction in GHG emissions attributed to the proposed changes to the NCC would be greater than estimated. Alternatively, if the electricity grid were to decarbonise faster than assumed, there would be a smaller reduction in GHG emissions attributed to the regulatory change. On the other hand, the accelerated decarbonisation may enhance the appeal of electrification as a more favourable option.

Moreover, the CRIS analysis does not quantify the amenity value related to some design changes such as choice of windows.

Conclusions

- **All three options under consideration are estimated to deliver significant net benefits compared with current NCC 2022 requirements.**
- **Based on the CBA results, Option 2 (an increase in the minimum energy efficiency requirements and mandatory rooftop solar) delivers the highest net benefits. However, the net benefits are only slightly (3 per cent) greater than Option 3.**
- **The central case scenario assumes that dual fuel buildings will be able to operate indefinitely. However, there is significant uncertainty around this future scenario. If dual fuel buildings will be required to convert to fully electric when the gas equipment needs replacing (after 20 years), the net benefits from Option 3 would be greater than Option 2.**
  - **In fact, if the probability of requiring electrification in 20 years is greater than 28 per cent, the expected net benefits from Option 3 would be greater than Option 2.**
- **Based on the CBA results, mandatory EV charging facilities delivers net costs. This element might need to be decoupled from the other requirements and considered separately.**

5 Hutley, N. 2023, *Economic parameters for technical work (NCC)*, report for Australian Building Construction Board, Rovingstone Advisory Pty Ltd, p. 4.

Next steps

The CRIS will be released for public consultation to inform the development of a Decision RIS in 2024. To assist with the consultation process, an online survey will be available on the ABCB's consultation hub for the duration of the consultation period for stakeholders to provide their feedback on the CRIS.

1 Introduction

Australia has committed to reduce greenhouse gas (GHG) emissions by 43 per cent below the 2005 level by 2030 and achieve net zero emissions by 2050. All Australian states and territories are committed to net zero emissions by 2050 or earlier, with varying interim targets for 2030.

Commercial buildings are a significant energy user and GHG emitter. It is estimated that there were more than 1 million commercial buildings in Australia by the end of financial year of 2020, with a gross floor area (GFA) of 830 million square metres estimated on a primary purpose basis.[6] These buildings consumed 267 petajoules (PJ) in FY2020, including 227 PJ of electricity and 40 PJ of gas, accounting for 23.8 per cent of Australia's total electricity consumption. They emitted 46.9 Mt CO_2-e of GHGs in the year, representing 9.4 per cent of Australia's total emissions.[7]

Improving the energy efficiency in commercial buildings is important to achieving emissions reduction targets.

Scope

For the purpose of this work, commercial buildings are defined as Class 2 common areas, Class 3 buildings and Class 5 to 9 buildings (table 1.1). As common areas of Class 2 building have similar characteristics to other commercial building classifications, for example an entrance hall to the lobby area of a hotel, and gyms and swimming facilities to those in Class 9b, they are not separately reported in this RIS.

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6 Strategy.Policy.Research. 2022, *Commercial Building Baseline Study 2022: Final Report*, prepared for Department of Climate Change, Energy, the Environment and Water, https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022, pp.iv-v
Note that the estimated GFA as at FY 2020 is not comparable to the estimated floor space (360 million square meters) in the CRIS 2019 for energy efficiency of commercial buildings. The 2019 estimate drew on a 'net lettable area' concept based on pitt&sherry (pitt&sherry, *Baseline Energy Consumption and Greenhouse Gas Emissions In Commercial Buildings in Australia*, Department of Climate Change and Energy Efficiency, 2012, https://www.energy.gov.au/sites/default/files/baseline-energy-consumption-part_1-report-2012.pdf, accessed 3 November 2023). GFA is a different concept and was not estimated in the CRIS 2019.

7 ibid.

1.1 Commercial buildings

Building class	Description
Class 2 common areas	Class 2 buildings are apartment buildings. They are typically multi-unit residential buildings where people live above and below each other. Class 2 buildings may also be single storey attached dwellings where there is a common space below. For example, two dwellings above a common basement or carpark. Only common areas of Class 2 buildings are considered as commercial buildings.
Class 3	Class 3 buildings are residential buildings other than a Class 1 or Class 2 building. They are a common place of long term or transient living for a number of unrelated people. Examples include a **hotel**, boarding house, guest house, hostel or backpackers (that are larger than the limits for a Class 1b building (a boarding house, guest house or hostel with a floor area less than 300m^2 and ordinarily having less than 12 people living in it).
Class 5	Class 5 buildings are **office** buildings that are used for professional or commercial purposes, excluding Class 6, 7, 8 or 9 buildings.
Class 6	Class 6 buildings are typically **retail** buildings such as shops, restaurants and cafés. They are a place for the sale of retail goods or the supply of services direct to the public.
Class 7	Class 7 buildings include two subclassifications: Class 7a and Class 7b.
Class 7a	Class 7a buildings are **carparks**.
Class 7b	Class 7b buildings are typically **warehouses**, storage buildings or buildings for the display of goods (or produce) that is for wholesale.
Class 8	A **factory** is the most common way to describe a Class 8 building. It is a building in which a process (or handicraft) is carried out for trade, sale, or gain. The building can be used for production, assembling, altering, repairing, finishing, packing, or cleaning of goods or produce. It includes buildings such as a mechanic's workshop. It may also be a building for food manufacture, such as an abattoir. A laboratory is also a Class 8 building.
Class 9	Class 9 buildings are buildings of a public nature, which include three subclassifications: Class 9a, Class 9b and Class 9c.
Class 9a	Class 9a buildings are generally **hospitals** which are referred to in the NCC as health-care buildings.
Class 9b	Class 9b buildings are assembly buildings in which people may gather for social, theatrical, political, religious or civil purposes. They include **schools**, universities, childcare centres, pre-schools, sporting facilities, night clubs, or public transport buildings.
Class 9c	Class 9c buildings are **aged care** buildings. Aged care buildings are defined as residential accommodation for elderly people who, due to varying degrees of incapacity associated with the ageing process, are provided with personal care services and 24-hour staff assistance to evacuate the building in an emergency.

Source: excerpt from ABCB 2022, *Understanding the NCC: Building Classifications*.

The following building types have not been explicitly modelled and are therefore not included in the CBA:

- apartment buildings (Class 2) common areas
- carparks (Class 7a)
- warehouses (Class 7b)
- factories (Class 8).

Energy efficiency in the NCC

Minimum energy efficiency standards for commercial buildings were first introduced into the Building Code of Australia (BCA), which now forms part of the National Construction Code (NCC), in 2006.[8] The minimum energy efficiency standards were subsequently updated, including substantial increases in stringency, in 2010 and 2019.

Proposed changes to the NCC

The Australian Building Codes Board (ABCB) is developing detailed options for updating the minimum energy efficiency requirements for commercial buildings. This effort is in alignment with a set of policies and high-level strategies that focus on energy efficiency, net zero emissions, and the promotion of electric vehicle uptake. The overarching goal is to have energy efficiency improvement and make substantial contributions to achieving emission reduction targets at both Commonwealth and jurisdiction levels.

The options have been developed in relation to the stringency levels of energy efficiency requirements (table 1.2):

1. Stringency Level 1: Cost-effective energy efficiency without mandated on-site photovoltaics (PV)

   Stringency Level 1 includes proposed energy efficiency provisions for better performance building envelope and equipment.
2. Stringency Level 2: Cost-effective energy efficiency with mandated on-site PV

   Stringency Level 2 introduces additional mandated on-site PV requirements to Stringency Level 1.
3. Stringency Level 3: Least-cost zero carbon ready buildings

   Stringency Level 3 covers least cost zero carbon provisions that achieve net zero GHG emissions ready buildings (when the grid decarbonises) with respect to regulated energy. This option extends Stringency Level 2 to provide full electrification readiness and to require additional PV to offset emissions from gas appliances compared with an all-electric equivalent. This means that under Stringency Level 3, a building's operational carbon emissions should be no higher than an equivalent all-electric building.

1.2 Options

Option	Scope
Option 1	Stringency Level 1 + EV charging facility requirements
Option 2	Stringency Level 2 + EV charging facility requirements
Option 3	Stringency Level 3 + EV charging facility requirements

Source: ABCB.

8 ABCB 2016, *NCC Volume One Energy Efficiency Provisions Handbook*, Fourth Edition, p. 20 and ABCB 2019, *Energy efficiency: NCC 2022 and beyond - Scoping study*, p. 4.

The proposed provisions will also be fuel and technology neutral under all options. This means the proposed NCC changes, at each stringency level, allow the use of suitable electric- and gas-powered equipment, provided the required overall level of efficiency and emissions is achieved.

However, noting that energy types will transition at different times for different building and different geographic areas, it is important to understand the impacts of a move to commercial buildings that are fully electric. While the impacts may vary, it is estimated this would not substantially alter the outcome of the analysis, particularly in relation to Stringency Level 3. Being near net zero, Stringency Level 3 requires a level of efficiency and emissions which favours the use of electric-powered equipment. Stakeholder feedback indicated that building industry is already moving towards fully electrifying commercial buildings, particularly office buildings. It is reasonable to adopt the analysis for Stringency Level 3 as also being applicable to fully electric new buildings.

For each of the stringency levels, there is the same mandatory requirement for EV charging facilities. More details about the options are provided in chapter 3.

Regulation Impact Statement

The ABCB has engaged the Centre for International Economics (CIE) to prepare a Consultation RIS (CRIS) that meets the Commonwealth Office of Impact Analysis (OIA) requirements, which are to answer seven key questions:[9]

- What is the policy problem?
- Why is government action needed?
- What policy options are to be considered?
- What is the likely net benefit of each option?
- Who was consulted and how was their feedback incorporated?
- What is the best option from those considered?
- How will the chosen option be implemented and evaluated?

This report

This report is a revised draft CRIS. It is prepared to assist a public consultation to provide feedback on impacts from proposed energy efficiency changes to NCC 2025 for commercial buildings. This CRIS will be further updated by incorporating relevant information and data collected throughout the public consultation process to a final decision Regulation Impact Statement (RIS) to support decision making.

9 ibid., p.7

Report structure

The remainder of this report is structured as follows:

- Chapter 2 discusses the nature and extent of the problems that the proposed changes in the NCC are seeking to address;
- Chapter 3 specifies the objectives and the proposed options;
- Chapter 4 discusses the impacts of the proposed options and approach to quantifying the impacts;
- Chapter 5 discusses the impacts at building level of proposed options;
- Chapter 6 reports aggregate impacts and the cost-benefit analysis (CBA) results; and
- Chapter 7 concludes.

More detailed discussions of specific issues are provided in appendixes.

2 *Statement of the problem*

A key element of a RIS is defining the problem that the Government is trying to address, including the nature and potential size of the problem.

The rationale for regulation

One way that government intervention in a market (including through regulation) can be justified is through identifying market failures and other behavioural anomalies that lead to inefficient outcomes.[10] Market failures and other behavioural anomalies in relation to the energy consumption associated with commercial buildings (including energy consumption associated with building operation and the transport emissions of building users) are discussed below.

A key market failure is that the full societal cost of consuming energy is currently not fully reflected in energy prices. In particular, the costs associated with GHG emissions that contribute to climate change are not directly reflected in energy prices. These costs are borne by the global community (see box 2.1 for a discussion on the global context).

2.1 Global context

Climate change caused by human activity is a global problem, requiring a global solution. GHGs in the atmosphere contribute to warming across the globe, regardless of where the emissions occur. In that sense, GHG abatement has the characteristics of a global public good. Specifically, GHG abatement is:

- non-excludable — individual countries cannot be excluded from receiving the benefits of limiting climate change; and
- non-rival — one country receiving benefits from limiting climate change does not prevent other countries from receiving the same benefits.

These characteristics mean that there is little incentive for each country individually to reduce GHG emissions to a level that will limit climate change. The costs associated with reducing GHG emissions are incurred domestically, while the benefits are spread across the globe. Each country therefore has an incentive to free-ride off the efforts of others.

Therefore, international Agreements are a crucial mechanism for achieving global action. The Paris Climate Agreement has been ratified by 195 of 198 Parties to the

10 See: Commonwealth of Australia, Department of Prime Minister and Cabinet, *Regulatory Impact Analysis Guide for Ministers' Meetings and National Standard Setting Bodies*, June 2023, p. 13.

United Nations Framework Convention on Climate Change (UNFCCC).[11] It aims to limit the increase of global average temperature to less than 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the rise to 1.5 degrees Celsius. In recent years, the need for limiting global warming to 1.5 degrees Celsius by the end of the century has been emphasised. To this end, GHG emissions must peak before 2025 at the latest and decline 43 per cent by 2030.[12]

Minimum energy efficiency standards for commercial buildings

The rationale for minimum energy efficiency standards is based on the proposition that industry would not make socially optimal energy efficiency decisions in commercial buildings without government intervention. That is, there are energy efficiency opportunities where the benefits to the community (including public benefits) outweigh the associated costs that would not be taken up in the absence of regulation. This is often referred to as the ‘energy efficiency gap’.[13]

Market failures and behavioural anomalies relating to energy efficiency

Market failures and behavioural anomalies that could contribute to the energy efficiency gap include the following.

- Negative externalities associated with energy consumption — unpriced negative externalities associated with energy consumption would normally mean that energy users do not take these costs into account in their decisions on whether to invest in energy efficiency. This creates an incentive for the commercial building industry to under-invest in energy efficiency in the absence of government intervention. Minimum energy efficiency standards can therefore encourage more socially efficient energy efficiency decisions. Unpriced negative externalities that have been identified in the literature include:
  – GHG emissions — see discussion above.
  – Peak demand —various studies have also suggested that costs associated with peak demand are not fully reflected in electricity prices.[14] Network capacity

11 United Nations Framework Convention on Climate Change, ‘Paris Agreement - Status of Ratification’, 2023, https://unfccc.int/process/the-paris-agreement/status-of-ratification, accessed 1 November 2023

12 United Nations Framework Convention on Climate Change, ‘The Paris Agreement’, 2023, https://unfccc.int/process-and-meetings/the-paris-agreement, accessed 1 November 2023

13 See for example, Gerarden, Todd D., Richard G. Newell, and Robert N. Stavins 2015, “Assessing the Energy Efficiency Gap”, *M-RCBG Faculty Working Paper Series*, 2015-04, Harvard Environmental Economics Program, January 2015, https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/files/mrcbg.fwp.2015-04.Stavins.efficiency.pdf.

14 See for example: ACIL-Allen, *National Construction Code 2022: Decision Regulation Impact Statement for a proposal to increase residential building energy efficiency requirements*, Report to the Australian Building Codes Board, 25 August 2022, p. 32.

and therefore infrastructure costs are driven by peak demand. Where the costs associated with peak demand are not reflected in electricity price, this would limit the incentive to invest in energy efficiency technologies that would reduce peak demand.

- Other market failures and behavioural anomalies — notwithstanding the market failures associated with energy pricing, it is often argued that policy measures to improve energy efficiency can deliver net private benefits through bill savings that outweigh the associated capital costs in addition to a reduction in GHG emissions (sometimes referred to as a 'win-win' outcome).[15] This implies there are energy efficiency opportunities that are privately cost effective that industry nevertheless fails to adopt. This is often referred as the 'energy efficiency paradox'.[16] Frequently cited market and behavioural failures that contribute to the energy efficiency paradox in relation to commercial buildings, include the following:
  - information failures (where the party making energy efficiency decisions does not have sufficient information to make rational decisions);
  - information asymmetries where the seller/landlord may have information on the energy efficiency of a building, but the buyer/tenant does not;
  - systematic behavioural biases (i.e. due to heuristic decision making and/or bounded rationality in the face of the sheer complexity of understanding energy efficiency options).
  - split incentives/principal-agent problem — this arises where the party making energy efficiency investment decisions is not responsible for paying the energy bills and can arise where the incentives affecting the builders making decisions that affect future buyers are not aligned to end-occupant/end-owner.
    - split incentives could occur between building owner or the landlord who bears the cost of any investment in energy efficiency and tenant who pays the energy bills;
    - split incentives may also occur between a building contractor and its owner and occupier. A building contractor makes many energy-related decisions. As energy efficient options usually increase the cost of construction, the contractor has incentives to choose less energy efficient alternatives, especially if the measures are not immediately obvious to the owner or prospective buyers;
    - another type of split incentive could occur within large organisations, where separate parts of the organisation are responsible for capital budgets and paying energy bills.

15 See for example former COAG Energy Council, *National Energy Productivity Plan 2015-2030: Boosting Competitiveness, managing costs and reducing emissions*, December 2015, p. 6.

16 Gerarden, T.D., Newell, R.G. and Stavins, R.N. 2015, *Assessing the Energy Efficiency Gap*, Duke University Energy Initiative and Harvard Environmental Economics Program, January 2015, p. 1.

Review of direct evidence on market failures and behavioural anomalies

Direct evidence on each of the market failures and behavioural anomalies identified above is summarised in table 2.2, with further discussion provided in Appendix A. In general, there is a sound in-principle case for minimum energy efficiency standards for commercial buildings on the following grounds.

- The primary justification for minimum energy efficiency standards in commercial buildings is that the external cost of GHG emissions is not reflected in energy prices under current policy settings. Although many commercial building owners have committed to net zero targets in their own operations, not all of these targets are being actioned, and not all owners and tenants have made such commitments. See appendix A for more details.
- In addition, although there is limited direct evidence, it is plausible that the following behavioural/organisational failures prevent privately cost-effective energy efficiency opportunities (i.e. where energy bill savings outweigh the associated capital costs) from being adopted.
  - Split incentives, including:
    - Different parts of an organisation are responsible for capital costs and operating costs (energy bills)
    - Different incentives across different parties in the building process
  - Behavioural anomalies, such as bounded rationality and heuristic decision making (such as building to code, rather than seeking the optimal mix of capital and ongoing energy costs); and inattention to non-salient energy costs are plausible explanations for the energy efficiency paradox across all building types.
- To the extent that behavioural anomalies mean that industry defers to the code, rather than seeking to optimise the balance between capital-related costs and ongoing operating costs, there may be a role for the code to drive industry towards best (or better) practice.

2.2 Summary of direct evidence of market failures and behavioural anomalies

Market failure or behavioural anomaly	Evidence	Existing measures to address	Unaddressed market failure or behavioural anomaly
Energy pricing			
External costs relating to GHG emissions	The current externality (i.e. the SCC) is estimated to be around 23.5 c/kWh.	Although there are no policies that directly internalise the social costs associated with GHG emissions, there is some evidence that some building owners and tenants do take GHG emissions into account in their decisions, largely reflecting Environmental, Social and Governance (ESG) commitments.	Not all building owners/tenants take into account GHG emissions in their decisions.
Externalities associated with peak demand	Consistent with AER pricing principles, costs associated with peak demand should be reflected in network pricing (albeit imperfectly).	AER pricing principles require that (i.e. any previous externalities should be address directly through pricing policies).	Although network tariffs may not reflect the costs associated with peak demand perfectly, any previously observed market failures are largely addressed.
Other market failures and behavioural anomalies			
Information failures (lack of information)	General evidence on the benefits of energy efficiency freely available. Project-specific information available commercially.	Governments and energy efficiency advocacy groups provide some information.	No unaddressed market failures.
Information asymmetries	No significant information asymmetries: The landlord/seller generally discloses ‘outgoings’ (including energy bills) to tenants/buyers.	Requirements to disclose outgoings to tenants. NABERS tools to benchmark actual energy performance against other similar buildings are available for most building types. Under the Commercial Building Disclosure (CBD) Program, a NABERS Energy rating is mandatory on sale or lease for office buildings >1000 m^2 .	No unaddressed market failures.
Landlord-tenant problem	No clear evidence of an information asymmetry problem, so the landlord-tenant problem unlikely to be a significant market failure in commercial buildings. Some split incentives apply during lease period.	Requirements to disclose outgoings to tenants. NABERS tools to benchmark actual energy performance against other similar buildings are available for most building types.	Landlord-tenant problem unlikely to be a significant contributor to the uptake of privately cost-effective energy efficiency opportunities.

Market failure or behavioural anomaly	Evidence	Existing measures to address	Unaddressed market failure or behavioural anomaly
		Under the CBD Program, a NABERS Energy rating is mandatory on lease for office buildings >1000 m^2.	
Other split incentives	Some qualitative evidence of split incentive where: ▪ Different parts of an organisation are responsible for capital costs and operating costs (energy bills) ▪ Different incentives across different parties in the building process.		Plausible that these split incentives contribute to sub-optimal outcomes.
Bounded rationality and heuristic decision-making	It is difficult to disentangle the role of heuristics and bounded rationality from competing explanations because decision-making processes cannot be directly observed. Qualitative evidence of heuristic decision-making, including entrenched practices in the construction industry, such as building to code, rather than optimising.	Government and industry awareness-raising efforts.	Plausible that heuristic decision-making — such as the persistence of entrenched practices and 'building to code' — is a barrier to the uptake of privately cost-effective energy efficiency opportunities.
Salience and inattention	While there is little direct evidence that inattention to energy costs leads to under-investment in energy efficiency, it is nonetheless a plausible explanation (particularly for small businesses).	Government and industry awareness-raising efforts.	Plausible that salience and inattention is a barrier to the uptake of privately cost-effective energy efficiency opportunities.

Note: See Appendix A for further information.

Source: CIE.

Rationale for government intervention on electric vehicle charging facilities

Passenger cars and light commercial vehicles contribute around 10 per cent of Australia's total GHG emissions.[17] However, the GHG emissions associated with petrol and diesel-powered combustion engines are not currently reflected in fuel prices (i.e. GHG emissions are an unpriced negative externality). This limits the incentive to transition to less GHG-intensive alternatives, such as electric vehicles

17 DCCEEW 2023, *The National Electric Vehicle Strategy*, Department of Climate Change, Energy, the Environment and Water, Canberra, p. 1.

(EVs). Transitioning to EVs (together with decarbonising electricity supply) is a key element of the pathway to net zero (see discussion on net zero targets below).[18]

There is an interdependence between EV adoption and investment in public charging facilities referred to as an 'indirect network effect' (or the chicken and the egg problem) This is where the benefit of adoption/investment on one side of the market increases with the network size on the other side of the market.[19]

- Although as much as 80 per cent of EV charging takes place at home, the availability of public charging facilities has been identified as a key barrier to widespread uptake of electric vehicles in Australia (along with high purchase price, beliefs around limited range, and long charging times at some stations).[20]
  - Even when EV owners can charge their vehicles overnight at home, some consumers still worry about running out of electricity before reaching their destination. This 'range anxiety' (which may partly reflect misunderstanding about EV range) limits adoption of electric vehicles, especially when public charging facilities are scarce.
  - Furthermore, according to the Electric Vehicle Council, it is likely that home charging will be challenging or impossible in around 20 per cent of the current dwelling stock, including:[21]
    - around 7 per cent of the dwelling stock on the market lacks off-street parking (for example, terrace housing)
    - around 14 per cent of the dwelling stock is flats and apartments where retrofitting EV charging facilities would be challenging or impossible.
  - Research from California indicates that around 20 per cent of consumers that had switched to an electric vehicle had switched back to petrol/diesel vehicles. Of these, 70 per cent lacked convenient charging facilities at home.[22]
- At the same time, private investors have less incentive to build charging stations if the size of the EV fleet is small.

Most commercial buildings are workplaces. Charging capabilities at work would provide an additional charging option, including for households that do not have access to charging at home.

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18 DCCEEW 2023, *The National Electric Vehicle Strategy*, Department of Climate Change, Energy, the Environment and Water, Canberra, p. 1.

19 Shanjun Li, Lang Tong, Jianwei Xing and Yiyi Zhou 2017, 'The Market for Electric Vehicles: Indirect Network Effects and Policy Design', *Journal of the Association of Environmental and Resource Economics*, January 2017, p. 88

20 DCCEEW 2023, *The National Electric Vehicle Strategy*, Department of Climate Change, Energy, the Environment and Water, Canberra, pp. 13-14.

21 Ross De Rango, Electric Vehicle Council, pers. comm. 10 October 2023.

22 Hardman, S. 2021, Understanding discontinuance among California's electric vehicle owners, *Nature Energy* 6, pp. 538-545.

Policy environment

It is important to understand the policy environment in relation to the NCC. In particular, whether there are existing policies that already address some or all of the market failures outlined above.

As achieving Australia's targets under the Paris Climate Agreement will require a suite of policies, it is important to understand where the NCC fits into the broader strategy.

The impact of the proposed changes to the NCC also depend on current and future policies.

GHG commitments

In 2022, under the Paris Climate Agreement, the Australian Government updated its Nationally Determined Contribution to target emissions reduction of:[23]

- 43 per cent below 2005 levels by 2030,
- net zero by 2050.

These targets have been legislated.

All Australian states and territories are committed to net zero emissions by 2050 or earlier, with varying interim targets for 2030. For example,

- Both New South Wales (NSW) and South Australia (SA) have an objective to achieve a 50 per cent reduction in emissions on 2005 levels by 2030;[24,25]
- Victoria (VIC) has set a target of 45-50 per cent below 2005 level by 2030, and 75-80 per cent by 2035, and net zero by 2045;[26]
- Queensland (QLD) has set a target of 30 per cent below 2005 level by 2030;[27]

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23 Department of Climate Change, Energy, the Environment and Water 2022, 'Net Zero', in *DCCEEW Emissions Reduction*, https://www.dcceew.gov.au/climate-change/emissions-reduction/net-zero, accessed 2 November 2023.

24 NSW Environment Protection Authority 2020, 'Net Zero Plan Stage 1: 2020–2030', in *NSW State of the Environment*, https://www.soe.epa.nsw.gov.au/all-themes/climate-and-air/net-zero-plan-stage-1-2020-2030, accessed 2 November 2023.

25 South Australian Department for Environment and Water, 'Mapping a pathway to net zero', in *Government of South Australia - Government Action on Climate Change*, https://www.environment.sa.gov.au/topics/climate-change/net-zero-pathway, accessed 2 November 2023.

26 Victorian Department of Energy, Environment and Climate Action 2022, 'Climate action targets', in *Victoria State Government - Climate Change*, https://www.climatechange.vic.gov.au/climate-action-targets, accessed 2 November 2023.

27 Queensland Treasury 2022, *Queensland Sustainability Report*, in *Action on climate change*, Queensland Government, December 2022, https://www.qtc.com.au/queenslands-sustainability-initiatives/, accessed 2 November 2023.

- Western Australia (WA) introduced the interim target of 80 per cent below 2020 levels by 2030 for all government agencies across the State;[28]
- Tasmania (TAS) has set the target to maintain net zero emissions or lower from 2030;[29]
- The Northern Territory (NT) is prioritising clean energy and renewables with its target of 50 per cent renewables for electricity supply by 2030;[30] and
- The Australian Capital Territory (ACT) is committed to achieving net zero by 2045, with targets of 50-60 per cent below 1990 levels by 2025, 65-75 per cent by 2030 and 90-95 per cent by 2040.[31]

High-level strategies

Several high-level strategies have either been developed or are being developed that will set out a roadmap for achieving the net zero target and other related objectives. Some of these high-level strategies that are relevant to the proposed changes to the NCC are set out below.

Sectoral decarbonisation plans

Consistent with the jurisdiction's net-zero emission agendas, the Australian Government will develop sectoral decarbonisation plans for six sectors, including the followings that are relevant to commercial buildings and the NCC:[32]

- Electricity and energy — decarbonisation of the electricity and energy sectors will reduce the GHG emissions associated with the operation of commercial buildings;
- The built environment — as commercial buildings form part of the built environment, changes to the NCC (including more stringent energy efficiency standards and requirements relating to rooftop solar) could form part of the decarbonisation plan;
- Transport — the decarbonisation plan for the transport sector is likely to involve a transition from diesel and petrol internal combustion engines to EVs. The

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28 Western Australian Department of Water and Environmental Regulation 2022, *Government Emissions Interim Target*, Western Australian Government, 2022, https://www.wa.gov.au/service/environment/business-and-community-assistance/government-emissions-interim-target,accessed 2 November 2023.

29 Tasmanian Department of State Growth 2023, 'Climate Change Action Plan', in *Renewables, Climate and Future Industries*, Tasmanian Government, https://recfit.tas.gov.au/climate/climate_change_action_plan,accessed 2 November 2023.

30 Northern Territory Government 2021, 'Territory Renewable Energy', Northern Territory Government, https://territoryrenewableenergy.nt.gov.au/, accessed 2 November 2023.

31 ACT Government 2021, 'ACT Climate Change Strategy', in *ACT Government Policy and programs*, https://www.climatechoices.act.gov.au/policy-programs/act-climate-change-strategy, accessed 2 November 2023.

32 Climate Change Authority website, https://www.climatechangeauthority.gov.au/parliament-refers-sectoral-pathways-review-climate-change-authority, accessed 3 November 2023.

provision of charging facilities at commercial buildings could assist with the transition.

The other sectors (that are less relevant to commercial buildings and the NCC) are: agriculture and land; resources; and industry and waste.

National Energy Performance Strategy

A consultation paper was released in November 2022 as a step towards a National Energy Performance Strategy. The term 'energy performance' encapsulates the broad management of energy demand, including:[33]

- energy efficiency
- load shifting
- fuel switching, and
- behaviour change.

The aim of the National Energy Performance Strategy is to provide a long-term framework for demand-side action to:[34]

- reduce pressure on energy bills
- improve energy reliability
- reduce emissions, and
- deliver a high energy performance economy.

The National Energy Performance Strategy aims at a holistic energy system planning for better energy performance that touches every industry of the economy and requires institutional coordination to govern energy performance in forms of industry policy – in the built environment, it sits with the Building Ministers and the ABCB. They are responsible for the development of the NCC that will reflect any plans of action – including energy efficiency and reducing emissions – to be developed under the Strategy.[35]

Trajectory for Low Energy Buildings

The *Trajectory for Low Energy Buildings* was agreed by Energy Ministers in February 2019. This is a national plan that sets the trajectory towards zero energy and carbon ready buildings for Australia. It proposed incremental changes to the NCC to reduce operational energy use and associated GHG emissions of residential and commercial buildings from 2022.

The trajectory effectively envisaged substantial upgrades to the minimum energy efficiency standards specified in the NCC for both residential and commercial

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33 Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, *National Energy Performance Strategy: Consultation Paper*, p. 3.

34 Ibid., p.1

35 Ibid., p.1

buildings at each triennial update cycle to ensure provisions keep pace with changing technologies and changing energy prices.[36]

In response to the Trajectory, the ABCB released a scoping study titled, *Energy efficiency: NCC 2022 and beyond*, for public comment. For both commercial and residential buildings, provision for the future installation of on-site renewables and EV charging was supported.[37] For commercial buildings, ABCB investigated moderate changes in NCC 2022, including work that complemented the residential energy efficiency provisions, such as research into the grid impacts of increased uptake of on-site renewable energy and research into provisions that accommodate the future installation of on-site renewable energy and EV charging.[38] The scoping study also envisaged more substantial changes for commercial buildings may be considered in NCC 2025.

National Electric Vehicle Strategy

The nationally agreed National Electric Vehicle Strategy was released in April 2023.

- The **vision** of the National Electric Vehicle Strategy is to increase the uptake of EVs to reduce emissions and improve the wellbeing of Australians.[39]
- The specific **objectives** are:
  - Supply — increase supply of affordable and accessible EVs
  - Systems and infrastructure — establish the resources, systems and infrastructure to enable rapid EV uptake
  - Demand — encourage increase in EV demand.
- The intended **outcomes** include to:
  - Expand EV availability and choice
  - Reduce road transport emissions
  - Make it easy to charge an EV across Australia
  - Increase local manufacturing and recycling
  - Make EVs more affordable
  - Reduce the cost to Australian of running their vehicles.

Of most relevance to the proposed changes to the NCC is the intention to make it easy to charge an EV across Australia. Making it easier for Australians to charge their cars is key to supporting the switch to EVs.[40]

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36 Former COAG Energy Council 2018, *Trajectory for low energy buildings*, December 2018, p. 5.

37 ABCB 2021, *Outcomes report: Energy efficiency NCC 2022 and beyond*, ABCB, 2021, pp.2-4.

38 ibid.

39 DCCEEW 2023, *National Electric Vehicle Strategy*, Department of Climate Change, Energy, the Environment and Water, Canberra, p. 3.

40 DCCEEW (2023), op. cit., p. 26.

Australian public service Net Zero Roadmap

The Australian public service Net Zero Roadmap sets out actions for the Australian Government to achieve net zero GHG emissions from its operations by 2030, through implementation of the Net Zero in Government Operations Strategy. The strategy outlines the approach and objectives to reduce emissions and transition to net zero in areas such as energy, electrification, EV charging, and fleet management.[41]

Key actions include:

- transitioning to renewable energy, facilitated through a whole-of-government coordinated procurement of electricity, to achieve 100 per cent renewable Commonwealth electricity
- improving building energy efficiency and promoting electrification, and
- transitioning the fleet to low- or zero-emission vehicles, with an objective of 75 per cent of new passenger vehicle orders to be low- or zero-emission vehicles by July 2025.

These actions are aligned with the proposed changes to the NCC which can facilitate the delivery of net zero commitment of the Australian Government to demonstrate leadership in reducing emissions by 2030.

Specific policies

Some specific policies that are relevant to the proposed changes to the NCC are set out below. This includes policies aimed at:

- encouraging greater energy efficiency in commercial buildings
- encouraging or mandating electrification of commercial buildings
- encouraging greater uptake of EVs.

Table 2.3 summarise how proposed changes in the NCC 2025 may support specific policies.

2.3 Specific policies and the implications for NCC 2025

Policies	Implications for NCC
NABERS provides a voluntary benchmarking tool that can encourage improved performance. Under the CBD Program, a NABERS Energy rating is mandatory for office buildings >1000 m^2 (along with a Tenancy Lighting Assessment) upon sale or lease.	▪ Encourages improved energy performance during operation. ▪ Complements mandatory minimum standards in the NCC.
ACT's ban of new gas connections to be rolled out in late 2023.	

41 Department of Finance 2023, 'APS Net Zero Emissions by 2030', in *Climate Action In Government Operations*, Australian Government , https://www.finance.gov.au/government/climate-action-government-operations/aps-net-zero-emissions-2030, accessed 12 January 2024.

Policies	Implications for NCC
Victoria's Gas Substitution Roadmap – phasing out new residential gas connections.	Jurisdictional schemes of electrification and bans of gas connection lay out changes to planning and building regulations. Electrification readiness considerations in NCC 2025 raise standards for commercial buildings will support the transition pathway and provide guidance of electric ready developments in jurisdictions.
Electric vehicle uptake incentives and fuel efficiency standards. For example, Victoria's Zero Emissions Vehicle Roadmap and the Australian Government's New Vehicle Efficiency Standard.	Considerations of charging facility installation in NCC 2025 to enhance EV-readiness of buildings, and by improving EV charging availability, they support EV uptake strategies across jurisdictions and the development of the mandatory fuel efficiency standard.

Source: CIE.

NABERS

The National Australian Built Environment Rating System (NABERS) is operated by the NSW Government on behalf of Commonwealth, State and Territory Governments. NABERS essentially provides a range of tools to benchmark performance on a range of sustainability measures against similar buildings. NABERS has been referenced in the NCC as an energy efficiency Verification Method. There are also NABERS tools in relation to: water, waste and indoor environment.

NABERS provides a rating from one to six stars as follows:[42]

- 1 star — making a start
- 2 star — below average
- 3 stars — average
- 4 stars — good
- 5 stars — excellent
- 6 stars — market leading.

Energy efficiency rating tools allow building owners/operators to obtain a rating for their building from an accredited assessor using an established methodology. These arrangements mean that buyers/tenants can have confidence in the energy efficiency rating provided by the seller/landlord.

Compared with 2018 (when the previous commercial energy efficiency RIS was completed) there are now NABERS Energy rating tools available for a broader range of buildings. NABERS Energy tools available for:

- Office buildings and tenancies
- Shopping centres
- Apartment buildings
- Hospitals (public)

42 NABERS 2018, 'What is NABERS?', Australian Government, 2018, https://www.nabers.gov.au/about/what-nabers, accessed 24 10 2023.

- Hotels
- Data centres
- Residential aged care
- Retirement living
- Warehouses and cold stores.[43]

The Commercial Building Disclosure Program

The Commercial Building Disclosure (CBD) Program is a key national-level policy to encourage energy efficiency improvements in existing buildings.

- Under the CBD Program, all office space greater than 1000 m^2 must obtain a Building Energy Efficiency Certificate (BEEC) upon sale or lease.
- A BEEC is prepared by an accredited assessor and includes:
  - a NABERS star rating that provides information on energy use, GHG emissions and a benchmark of how energy use compares to similar buildings in similar climatic locations;
  - the lighting efficiency of the tenanted area through a Tenancy Lighting Assessment (TLA). This provides a measure of the energy required to light each of the areas of a building.
- The NABERS rating must be disclosed in all advertising material.

The CBD Program provides benchmarked energy performance information that can be useful to both the building owner (i.e. the landlord) and buyers/tenants.

The CBD Program was intended as a complement to mandatory minimum standards set out in the NCC. Whereas the NCC applies only to new buildings (and buildings undergoing major refurbishment), the CBD Program aims to encourage improved energy performance of existing buildings.

State and territory-based electrification policies

The ACT and VIC have taken proactive steps in electrification policies.

The ACT government is committed to net-zero emissions target by 2045 with plans of action and transition pathway to electrify fossil fuel energy by 2045. Some milestones that are achieved or to be expected in near future include:[44]

- In 2020 the ACT secured 100 per cent renewable electricity supply.
- Community consultation on a regulation to prevent new gas network connections was held in 2023.
- A regulation to prevent new gas network connect rolled out in December 2023.

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43 NABERS 2020, 'NABERS Energy', Australian Government, 2020, https://www.nabers.gov.au/ratings/our-ratings/nabers-energy, accessed 16 October 2023.

44 ACT Government 2023, 'Powering Canberra: Our Pathway to Electrification', in *ACT Government - Canberra is Electrifying*, 2023, https://energy.act.gov.au/, accessed 2 November 2023.

- ACT Government released the *Integrated Energy Plan Position Paper* that proposed approaches to transform ACT energy system for public comments. The Integrated Energy Plan will outline actions to be taken over the short and long term along a transition pathway to an affordable and sustainable energy systems. This plan is expected to be published in 2024.[45]

The VIC government set out the Victoria's Gas Substitution Roadmap to guide the state to meet its net zero emission targets. The roadmap lays out key regulatory steps and support programs as follows.[46]

- From January 1st 2024 onwards, the phase-out policy will be rolled out to limit new gas connection for new dwellings, apartment buildings and residential subdivisions. This policy will affect the construction of new dwellings with planning permits.
- The Roadmap Update in January 2024 reiterates 'investigating options to progressively electrify all new and existing residential and most commercial buildings'.
- Solar Victoria is launching the residential electrification grants program, offering grants to providers involved in large-scale residential electrification projects across Victoria. These grants will benefit homeowners. Solar Victoria also provides individual rebates for solar PV for new homes under construction. Additionally, they offer training programs to support electricians in designing and installing PV and batteries in new homes.

There appears to be no active consideration of policies to support electrification (or the phasing out of gas) in other states and territories.

Electric vehicle incentives

There are six categories of financial incentives for purchasing zero- or low-emission vehicles across jurisdictions as follows.[47] They encourage uptake of electric vehicles, implying a need for consideration of safe charging in the built environment.

- **Rebates** with eligibility requirements on dutiable values and/or total household taxable income are offered in NSW, QLD, SA and WA.

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45 ACT Government 2023, *Position Paper: Developing ACT's Integrated Energy Plan - Canberra is electrifying towards a net zero emissions city*, ACT Government, August 2023, pp.1-11.

46 Planning Victoria 2023, 'Victoria's Gas Substitution Roadmap', in *the Victorian Government - Renewable energy*, 2023, https://www.planning.vic.gov.au/guides-and-resources/strategies-and-initiatives/victorias-gas-substitution-roadmap, accessed 2 November 2023.
Victoria State Government 2024, *Victoria's Gas Substitution Roadmap Update: Victoria's Electrification Pathway*, p. 3, https://www.energy.vic.gov.au/__data/assets/pdf_file/0027/691119/Victorias-Gas-Substitution-Roadmap-Update.pdf, accessed 7 February 2024

47 Electric Vehicle Council 2023, *State of Electric Vehicles Report 2023*, 31 July 2023, pp. 33–34.

  - The NSW Government offered $3,000 rebates for new full battery electric vehicles and hydrogen fuel cell electric vehicles registered between 1 September 2021 and 1 January 2024.[48]
  - The Victoria Government provided subsidies to just under 10,000 zero emissions vehicles (ZEVs) under the Zero Emissions Vehicle Subsidy Program which was the first such program in Australia and are now closed.[49]
  - The QLD Government will offer $6,000 rebate for a new eligible zero-emission vehicle.[50]
  - A $3,000 subsidy was available for new battery electric and hydrogen fuel cell vehicles registered in SA between 28 October 2021 and 1 January 2024.[51]
  - The ZEV rebate scheme will provide a ZEV owner with a $3,500 rebate after purchasing an eligible vehicle in WA.[52]
- **Registration exemptions or discounts** are offered in ACT, NT, QLD, SA and VIC
  - The ACT Government is offering 2 years of free registration for new or used zero-emissions vehicles acquired before 30 June 2024.[53]
  - The NT Government is offering free registration for new and existing battery electric vehicles and plug-in hybrid electric vehicles until 30 June 2027.[54]

48 Revenue NSW 2021, 'Electric Vehicle Rebate', in *Grants and schemes*, NSW Government , 2021, https://www.revenue.nsw.gov.au/grants-schemes/electric-vehicle-rebate, accessed 2 November 2023.

49 https://www.solar.vic.gov.au/zero-emissions-vehicle-subsidy

50 Queensland Rural and Industry Development Authority 2023, 'Queensland Zero Emission Vehicle Rebate Scheme', in *Grants and Programs*, Queensland Government, 2023, https://www.qrida.qld.gov.au/program/queensland-zero-emission-vehicle-rebate-scheme, accessed 2 November 2023.

51 Department of Treasury and Finance 2021, 'Incentives for electric vehicles', in *Growing South Australia*, Government of South Australia, 2021, https://www.treasury.sa.gov.au/Growing-South-Australia/incentives-for-electric-vehicles, accessed 2 November 2023.

52 Department of Transport 2023, 'Zero Emission Vehicle (ZEV) Rebate', in *Electric vehicles* , Government of Western Australia, 2023, https://www.transport.wa.gov.au/projects/zero-emission-vehicle-zev-rebate.asp, accessed 2 November 2023.

53 Access Canberra 2023, 'Incentives for low and zero emissions vehicles', in *Registration*, ACT Government, 2023, https://www.accesscanberra.act.gov.au/driving-transport-and-parking/registration/incentives-for-low-and-zero-emissions-vehicles, accessed 2 November 2023.

54 Northern Territory Government 2022, 'Get registration and stamp duty concessions for electric vehicles', in *Registration and number plates*, https://nt.gov.au/driving/rego/getting-an-nt-registration/get-electric-vehicle-registration-and-stamp-duty-concessions>, accessed 2 November 2023.

  - The QLD Government offers registration discount on hybrid or electric vehicles.[55]
  - A 3-year registration exemption is offered in SA for eligible new battery electric and hydrogen fuel cell vehicles first registered from 28 October 2021.[56]
  - In VIC, zero- or low-emission vehicles receive $100 registration concession.[57]
- **Stamp duty exemptions or discounts**
  - No stamp duty is payable on eligible zero- or low-emission vehicle purchases in ACT,[58] NSW,[59] and NT.[60]
  - In QLD zero- or low-emission vehicles are offered a reduced stamp duty cost.[61]
- In ACT an **interest free loan** up to $15,000 is offered in purchase of eligible energy-efficient projects including electric vehicles in ACT.[62]
- **Road user charges**
  - No road user charges are payable except in VIC.[63] However, the High Court recently overruled the imposition of road user charge to VIC EV owners.[64] The levy is set to be removed.

55 Queensland Government 2023, 'Shifting to zero emission vehicles', in *Electric vehicles*, 2023, https://www.qld.gov.au/transport/projects/electricvehicles/hitting-the-road, accessed 2 November 2023.

56 Department of Treasury and Finance, Government of South Australia (2021), *op. cit.*

57 VicRoads 2019, 'Hybrid vehicle registration discount', in *Concessions & discounts*, 2019, https://www.vicroads.vic.gov.au/registration/registration-fees/concessions-and-discounts/hybrid-vehicle-registration-discount, accessed 2 November 2023.

58 Access Canberra (2023), op.cit.

59 NSW Treasury 2021, 'No stamp duty payable on electric vehicle purchases', NSW Government, 2021, https://www.nsw.gov.au/driving-boating-and-transport/nsw-governments-electric-vehicle-strategy/abolish-stamp-duty, accessed 2 November 2023.

60 Northern Territory Government (2022), *op. cit.*

61 Royal Automobile Club of Queensland 2022, 'Incentives make electric cars more affordable', in *EVs*, 2022, https://www.racq.com.au/articles/evs/2022/11/incentives-make-electric-cars-more-affordable, accessed 2 November 2023.

62 ACT Government 2022, 'Sustainable Household Scheme', in *Climate Choice*, 2022, https://www.climatechoices.act.gov.au/policy-programs/sustainable-household-scheme, accessed 2 November 2023/

63 VicRoads 2021, 'ZLEV road-user charge', https://www.vicroads.vic.gov.au/online-services/help-centre/partner-help-centre/zlev-road-user-charge, accessed 2 November 2023

64 P Karp & B Kolovos, 'High court strikes down Victoria's electric vehicle tax in ruling that could threaten other state levies', in *The Guardian*, 18 October 2023, section Environment, https://www.theguardian.com/environment/2023/oct/18/victoria-electric-vehicle-tax-high-court-ruling-could-impact-nsw-wa-western-australia, accessed 3 November 2023.

  - The High Court's decision may hold off the introduction of the levy to EV owners in NSW and WA by 2027.[65]
- **Fringe benefits tax exemption**
  - Since 1 July 2022 employers do not pay fringe benefits tax on electric vehicles not subject to luxury car tax and associated expenses. Benefits provided under a salary packaging arrangement are included in the exemption.[66]

Fuel efficiency standard

As a key part of the Electric Vehicle Strategy, the Australian Government has committed to introducing a fuel efficiency standard.[67]

A fuel efficiency standard is an obligation on light vehicle suppliers to make sure the new vehicles they bring into the market, on average, meet a particular CO_2 per kilometre standard.[68]

- Where suppliers exceed the standard by selling more efficient vehicles (including EVs), they are rewarded (usually through 'credits').
- Where suppliers do not meet the standard, by selling proportionally more higher emissions vehicles, they are penalised (this could include: a requirement to buy credits from other suppliers or pay a fine).

Over 85 per cent of the global car market has vehicle fuel efficiency standards, with Australia one of the only advanced economies without a mandatory one.[69] The absence of a fuel efficiency standard in Australia has been identified as a key reason why EV models are not supplied to the Australian market.[70]

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65 Zaunmayr, T. 2023, 'Vic court ruling could scupper WA EV road tax', in *Business News*, 18 October 2023, https://www.businessnews.com.au/article/Vic-court-ruling-could-scupper-WA-EV-road-tax, accessed 3 November 2023; and J Skatssoon, 'NSW reconsiders EV road user charge after High Court decision', in *Government News*, 23 October 2023, https://www.governmentnews.com.au/nsw-reconsiders-ev-road-user-charge-after-high-court-decision/, accessed 3 November 2023.

66 Australian Tax Office 2024, 'Electric cars exemption', https://www.ato.gov.au/businesses-and-organisations/hiring-and-paying-your-workers/fringe-benefits-tax/types-of-fringe-benefits/fbt-on-cars-other-vehicles-parking-and-tolls/electric-cars-exemption, accessed 8 February 2024.

67 Department of Infrastructure, Transport, Regional Development, Communications and the Arts website, https://www.infrastructure.gov.au/infrastructure-transport-vehicles/vehicles/australian-fuel-efficiency-standard-cleaner-cars-australia, accessed 3 November 2023.

68 Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts 2023, *The Fuel Efficiency Standard — Cleaner, Cheaper to Run Cars for Australia*, Consultation Paper, 19 April 2023, p. 10.

69 DCCEEW 2023, *National Electric Vehicle Strategy*, Department of Climate Change, Energy, the Environment and Water, Canberra, p. 1.

70 DCCEEW (2023), *op. cit.*, p. 21.

A fuel efficiency standard is expected to improve the supply and variety of EVs coming into the Australian market,[71] and support the increased uptake of EVs.

The case for change

Key drivers for change to the NCC (discussed in detail below) are as follows:

- Governments (including both Commonwealth, state and territory governments) have committed to net zero policy targets, which will require greater ambition across a range of policy areas;
- Increasing the stringency of the minimum energy efficiency standards and mandating EV charging facilities in commercial buildings would represent tangible policy action consistent with emerging strategies to achieve net zero targets; and
- Recent (2022) economic modelling that supports greater cost-effective stringency, coupled with more recent increases in estimates for the cost of both carbon emissions and energy prices that further enhance the economic case.

Policy drivers

A key recent policy development (since the previous change to the NCC minimum energy efficiency standards in 2019) is the net zero commitment, which has been legislated. Achieving the revised target will require greater policy ambition across a range of decarbonisation initiatives, including stationary energy.

In addition, changes to the NCC would represent policy action consistent with broader strategies, including:

- The Trajectory for Low Energy Buildings
- the National Energy Performance Strategy (although this strategy has not been finalised, the proposed changes to the NCC are consistent with improved energy performance)
- the National Electric Vehicle Strategy.

Other developments

The cost effectiveness of energy efficiency measures depends fundamentally on the price of energy, the cost of energy efficient technologies and designs relative to alternatives (which may change due to technological advances).

Despite significant increases over the past couple of years (due in part to global events, such as the Russian invasion of Ukraine), retail electricity prices have declined in real terms since the 2018 RIS (based on the CPI measure), although there has been a significant real increase in retail gas prices.[72]

71 DCCEEW (2023), *op. cit.*, p. 1.

72 ABS, Consumer Price Index — September Quarter 2023.

On the other hand, there is a strong case to place a higher value on reducing GHG emissions on the following grounds:

- Recent advances in the scientific literature on climate change and its economic impacts suggest the damage caused by climate may be worse than previously estimated. For example, Newman and Noy (2023) found that frequently cited estimates of the economic costs of climate changed arrived at by using Integrated Assessment Models may be substantially underestimated.[73] These advances have been reflected in an upward revision in the US Environmental Protection Agency's estimate of the social cost of carbon.[74]
- As Australia has committed to deeper cuts in carbon emissions the implicit value of abatement will be higher.

As a result of these developments, the range of socially cost-effective energy efficiency opportunities are likely to have changed.

Inefficiencies in the existing code

The technical work conducted by DeltaQ suggests that there are currently several inefficiencies reflected in the current code, including the following:

- The NCC currently treats 'internal' walls, such as walls around the lift well to be part of the building envelope. As such, these walls must be insulated to comply with NCC requirements; insulating these walls has little to no impact on the building's energy efficiency performance.
- The minimum insulation requirements for some buildings are currently excessive, particularly for buildings that typically operate during the daytime only. These excessive insulation requirements may reduce energy performance in warmer climates where cooling requirements dominate. In particular, excessive insulation can trap heat in the building and increase the energy required to cool the building to a comfortable temperature when the air-conditioning is switched on in the morning. This effect can outweigh the benefits from better insulated walls.
- Plant efficiency requirements are not specified in terms of the design loading, which may encourage (or fail to discourage) over-sizing of plant.

Importantly, changes to the code that address these existing inefficiencies create the potential to simultaneously reduce capital-related costs and improve energy performance.

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73 Newman, R. and Noy, I. 2023, The global cost of extreme weather that are attributable to climate change, Nature Communications, https://www.nature.com/articles/s41467-023-41888-1, accessed 3 November 2023.

74 US Environment Protection Agency 2022, *Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review"*, EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances, September 2022, p. 3.

Modelling showing cost effective energy efficiency opportunities in commercial buildings

Modelling of cost-effective options for increasing the minimum standards in the NCC, *Achieving Lower Energy Commercial Buildings in Australia*, was prepared for the (then) Department of Environment and Energy in 2018 as part of the Trajectory for Low Energy Buildings work program.[75] This modelling was updated in 2022. Key findings from the updated modelling included the following:[76]

- A weighted average reduction in energy intensity of 26 per cent could be achieved cost-effectively through increases in the stringency of the minimum energy efficiency standards in the NCC for commercial buildings.
- Together with future changes to the NCC in 2028 (involving further savings of 9.8 per cent) and 2034 (involving further savings of 9 per cent), this is estimated to deliver:
  - net social benefits of $8.2 billion in net present value terms over an assumed 40-year life (using a discount rate of 7 per cent) of buildings constructed over the period from 2026 to 2050 (meaning that some benefits will persist through to 2090)
  - energy savings reaching 56 PJ by 2050
  - cumulative GHG emission savings of 70 Mt CO_2-e by 2050.

75 See: DeltaQ and Strategy.Policy.Research. 2018, *Achieving Low Energy Commercial Buildings in Australia*, Final Report, 9 November 2018.

76 DeltaQ and Strategy.Policy.Research. 2022, *Commercial Buildings Low-Energy Trajectory, NCC 2025 Update to Achieving Low Energy Commercial Buildings in Australia*, Final Report, Prepared for the Department of Industry, Science, Energy and Resources on behalf of all States and Territories, 10 March 2022, p. 2.

3 Objectives and options

Objectives

The energy efficiency changes in the NCC initiated from the National Energy Productivity Plan in 2015, which followed by a national plan— *Trajectory for Low Energy Buildings* (the Trajectory) in 2019 to set a trajectory towards zero energy (and carbon) ready buildings. With the GHG emission reduction targets legislated in 2022, Energy Ministers agreed to support the changes that achieve a low energy, net zero carbon building sector by 2050.

The Guide to Section J1P1 of the NCC (the Performance Requirement in relation to energy efficiency) states that the objective of Section J is to 'align with policy set by governments in the Trajectory for Low Energy Buildings', to reduce energy consumption and energy peak demand, to reduce GHG emissions, and to improve occupant health and amenity.[77]

That said, policies aimed at improving energy efficiency often have a broader set of objectives. For example, the consultation paper on the National Energy Performance Strategy notes the following benefits from improving energy performance in addition to reducing GHG emissions:[78]

- lowering consumer energy costs,
- taking pressure off the system, and
- improving health and comfort.

The draft NCC 2025 energy efficiency project briefing has stated that the objectives of energy efficiency work are, in order of importance, to:[79]

- reduce GHG emissions,
- reduce commercial building running costs,
- make commercial buildings more resilient to heatwaves, and
- assist with the decarbonisation of the electricity grid.

77 ABCB 2022, *National Construction Code: Housing energy efficiency Handbook*, 2022, https://www.abcb.gov.au/sites/default/files/resources/2023/NCC-2022-Housing-energy-efficiency-handbook-fa.pdf, pp. 5-6.

78 DCCEEW 2022, *National Energy Performance Strategy: Consultation Paper*, Australian Government Department of Climate Change, Energy, the Environment and Water, November 2022, pp. 3-4.

79 ABCB 2022, *NCC 2025 energy efficiency project: Rationale and Scope*, 2022, p.1

Options

Base case: Maintain the status quo

The base case establishes the baseline against which the proposed changes are compared. It is essentially the status quo, that is, new builds compliant with NCC 2022.

The base case must also account for the extent to which new buildings go beyond the minimum requirement in the NCC 2022, reflecting voluntary adherence to higher standards including voluntary uptake of on-site PV. In this context, the base case may also reflect certain non-regulatory alternatives.

Non-regulatory options

RIS guidelines require that a RIS identifies a range of viable options. These include, as appropriate, non-regulatory, self-regulatory, quasi-regulatory and co-regulatory options.[80]

In this context, a more flexible alternative option to encourage improved energy efficiency performance of commercial buildings would focus on providing relevant information to users and managers of commercial building. This could involve presenting the proposed changes as a voluntary guideline or within a handbook.

To the extent that voluntary changes do not face barriers in the form of information or market failures, it would be expected that these would already be adopted and therefore form part of the base case.

Policy options

Three policy options are developed equivalent to the three stringency levels developed by the ABCB:

- **Stringency Level 1: Cost-effective energy efficiency without mandated on-site photovoltaics (PV)** — includes proposed energy efficiency provisions for better performance building envelop and equipment.
- **Stringency Level 2: Cost-effective energy efficiency with mandated on-site PV** —introduces additional mandated on-site PV requirements to Stringency Level 1.
- **Stringency Level 3: Least-cost zero carbon ready buildings** —covers least cost zero carbon provisions that achieve net zero GHG emissions ready buildings (when the grid decarbonises) with respect to regulated energy. This option extends Stringency Level 2 to provide full electrification readiness and to require additional PV to offset emissions from gas appliances compared with an all-electric equivalent. This means that under Stringency Level 3, a building's

80 Commonwealth of Australia, *Regulatory Impact Analysis Guide for Minister's Meetings and National Standard Setting Bodies*, 2023, https://oia.pmc.gov.au/sites/default/files/2023-06/regulatory-impact-analysis-guide.pdf, accessed 16 Oct 2023.

operational carbon emissions should be no higher than an equivalent all-electric building.

There is a mandatory requirement on EV charging under all options. The proposed provisions will also be fuel and technology neutral under all options.

Table 3.1 provides a schematic summary of the requirements for each of the three options.

3.1 Options of proposed changes

Proposed changes	Option 1	Option 2	Option 3
Stringency Level	1	2	3
Increased DTS stringency for envelope and services	✓	✓	✓
Mandatory EV charging	✓	✓	✓
Mandatory on-site PV	×	✓	✓
Additional PV requirement to offset gas appliance	×	×	✓
Electrification ‘readiness’ requirement	×	×	✓

Source: ABCB.

Option 1: Cost-effective energy efficiency without mandated on-site PV plus EV charging requirements

This option (Stringency Level 1 plus EV charging requirements) includes energy efficiency provisions for better performance building envelop and equipment.

This option is expected to reduce energy consumption of a building by between 20 to 50 per cent in comparison to NCC 2022 provisions. In isolation it is insufficient for Australia’s 2050 Net Zero target.

Option 2: Cost-effective energy efficiency with mandatory on-site PV plus EV charging requirements

This option includes mandatory on-site PV system in addition to the Option 1 (Stringency Level 1). It requires a PV system size to cover the majority of buildings’ available roofspace.

Performance Requirements will allow the use of other forms of on-site renewables.

Battery storage is not considered as it is found not be cost-effective as an individual measure for all stringency levels.[81]

According to the energy modelling that assesses the energy use, GHG emissions and cost implications, mandatory onsite PV would be beneficial, but mandatory onsite

81 DeltaQ 2023, *NCC 2025 Energy Efficiency - Initial Measures Development: Electrical Services Report*, The Australian Building Codes Board, September 2023, pp. 39–40.

battery storage would not be beneficial. Further detail on this investigation is provided in the section below on ‘Summary of changes to provisions’.

Buildings that voluntarily adopt an all-electric approach have the potential to approach a near Net Zero level. However, it is not the case for dual-fuel buildings.

Option 3: Least- cost net zero carbon ready buildings plus EV charging requirements

This option extends Option 2 to require additional PV to offset emissions from gas appliances compared with all-electric equivalent and providing electrification readiness, for example gas-powered space heating and domestic hot water systems. This option potentially could lead to higher costs for buildings with gas appliances than full electric buildings. Also considering limitations due to roof size, or orientations, this could drive those buildings to be transitioned to electric, although the proposed changes do not mandate electric buildings.

This option investigates where it is practicable to increase the stringency of the “cost-effective” Deemed-to-Satisfy (DTS) measures. It is found that envelope measures and some refinement to heating, ventilation, and air conditioning (HVAC) controls are able to be increased. It is found, however, that all other areas had reached their technical or market availability limits under Stringency Level 1. For example, it would be cost effective to have more insulation but it makes much more impractical to build the wall. Similarly, dark windows save money but getting too dark leads to amenity issues. On market availability, chillers are a good example. The most efficient chiller is cost effective, but if the requirement is set at the most efficient level, only one or two companies could provide equipment. As a result the efficiency level is set where there is diversity in manufacturers providing products.

A broader range of options including higher efficiency envelope and services, or alternate renewable energy sources can be used under the Verification Measures or a Performance Solution.

In the longer term, this option is expected to achieve near net-zero emissions as the electricity grid decarbonises and through the eventual replacement of gas appliances with electric ones.

Summary of changes to provisions

Performance requirement

Performance Requirement J1P1

Three updated versions of J1P1, reflecting each stringency level, have been developed for the Public Comment Draft (PCD). For Stringency Levels 2 and 3, the proposed Performance Requirement explicitly addresses operational GHG emissions, aligning with the broader scope of these scenarios which reaches beyond energy efficiency. Quantified near-zero GHG emissions levels are proposed for Stringency Level 3.

This approach is fuel-agnostic and would allow for the use of gas if a sufficient level of efficiency and offsets can be achieved overall.

For all stringency levels, elements relating to solar radiation, energy source and sealing of the building are proposed to be deleted on the basis that the quantified regulated energy Performance Requirement renders them no longer necessary. The recommended regulated energy consumption limits for each stringency level may be refined over the coming months as DeltaQ undertakes further analysis in response to comments received and to support the impact assessment.

Performance Requirement J1P4

J1P4 has been updated to support the mandatory installation of EV chargers in Class 3 and 5 to 9 buildings. This change is proposed for all three stringency levels. The Performance Requirement is quantified through consideration of the distance driven by the building occupants. This allows flexibility across building classifications and locations.

For mandatory on-site PV, the requirement is to achieve the performance target for regulated energy and GHG emissions in Stringency Level 2 and 3version of J1P1 that can only practically be achieved through the use of an on-site renewable energy system.

Verification Methods

Updates have been incorporated into J1V1 (NABERS) and J1V3 (Verification using a Reference Building). These changes apply across all three stringency scenarios. J1V2 and J1V4 are unchanged.

In J1V1, the changes are to reflect an enhanced overall stringency and to simplify the modelling requirements.

J1V3 has two significant changes proposed. Firstly, it is proposed to remove the ability to offset the performance of a building's envelope with PV. This was considered no longer appropriate given the higher level of overall stringency now required.

Secondly, it is proposed to introduce a requirement for a building's total proposed energy use to be at least 10 per cent better than the reference building. This brings the J1V3 modelling process in line with the requirements of J1V1 and J1V2.

Building envelopes

Roofs

For roof colour, it is proposed to replace the existing solar absorptance DTS metric with a choice of either Solar Reflectance Index (SRI) or total solar reflectance and thermal emittance. For general roof areas, the overall level of stringency proposed is equivalent to NCC 2022. The overall number of roof colour choices is equivalent between NCC 2022 and 2025 other than for metal roofs in Climate Zones 1, 2, 3, 5 and 6 which have air-conditioning plant and outside air intakes placed on the roof or within 2m above it. There are specific provisions for higher reflectance and emittance for these roofs to reduce cooling load.

It is proposed to increase the stringency of the roof insulation and wall thermal resistance requirements. These changes are based on the outcomes of the technical analysis and will not only decrease annual building energy consumption but will also reduce building peak energy demand.

Wall-Glazing construction[82]

Proposed wall-glazing changes aim to reduce solar admittance for wall-glazing in all building classifications and climate zones other than climate zone 8. This revision is based on models that have a higher stringency for Façade Solar Admittance in 2025 in comparison to 2022. Importantly, the building archetypes used in the modelling of wall-glazing construction were tested to ensure they had adequate natural light using the Spatial Daylight Autonomy (sDA) metric, rather than daylight factor, which was used to develop the NCC 2019 provisions. sDA is more sensitive to orientation, occupied times and glare, and achieves an "adequate" level of daylighting with a lower combination of glazed area and visual light transmittance than daylight factor. However, the NCC only regulates daylight to Class 2, 3, 4 and 9 buildings (through F6P1), meaning that the existing daylighting requirements of Part F Health and Amenity will be met and likely exceeded in the models that underpin all three stringency levels.

The glazing change values are derived using moderate window-to-wall ratios for each archetype (i.e. building form modelled). Stringency Level 3 values are derived using lower but still realistic window-to-wall ratios for each archetype.

These changes significantly reduce building cooling requirements and related energy use, and reduce the required cooling system capacity. This reduction in plant capacity represents a significant cost saving for builders, especially in larger builds.

There are also changes to Total System U-Value requirements proposed under each scenario. These are less significant, but will reduce building heating requirements in certain circumstances, but increase it slightly in others. These will have a modest impact on design, with buildings able to maintain window-to-wall ratios and daylighting similar to NCC 2022 compliant buildings.

Changes to the provisions for the Total System U-Value and solar admittance of wall-glazing constructions are proposed, which apply the requirements on a per storey basis, preventing trade-offs between storeys in the DTS Provisions. A back-stop value for the Total System U-Value of glazing has also been proposed to prevent

82 Additional glazing requirements are included in the Public Comment Draft under Stringency Level 3, which are not included in the building level cost-benefit analysis. Hence the impact of the additional glazing requirements is not covered in this report.

the use of unrealistically high-performing glass. This is analogous to the opaque wall value backstop and also prevents gaming of J1V3.

A change to the defined term ‘envelope’ is also proposed. The proposed change clarifies where the term envelope is meant to apply and will, thereby, reduce construction costs. At present, an envelope wall is defined as building fabric between conditioned space and unconditioned space, including internal walls. Under the present definition, the fabric around any internal unconditioned spaces, that are wholly or mostly enclosed, such as lift shafts or stair wells, are required to meet the minimum Total System U-Value requirements of Part J4D6. This leads to unnecessary installation of insulation against spaces that would be expected to be close to the same temperature as the conditioned areas they adjoin.

Vertical Shading

It is proposed to introduce new DTS Provisions that set minimum standards for vertical shading. Presently DTS Provisions exist for horizontal shading, but only vertical shading that blocks 80 per cent of direct summer solar radiation is accommodated within the DTS. Providing more comprehensive DTS Provisions for vertical shading will facilitate the installation of vertical shading, which is particularly effective in controlling solar gain from the western aspect and will help control air-conditioning peak demand in summer.

Building sealing

Proposed revisions to the building sealing provisions in Part J5 seek to clarify the intent and application of the provisions. The changes remove duplication and align terminology used to describe the location of the thermal boundary with other Parts of Section J. The changes also clarify the scope of the airlock requirements to exempt spaces with moveable external walls, and clarify the scope of sealing walls, ceilings, and floors to include interface to ventilation openings. The intent of the revisions is to clarify rather than change the stringency, although some individual practitioners may adopt more or less stringent practices as the changes promote a more consistent interpretation across the industry.

HVAC

Air conditioning controls

The changes to the provisions for air conditioning controls will restrict simultaneous heating and cooling, prevent poor zone design and respond to feedback from industry that the current provisions were subject to gaming in establishing the J1V3 reference building.

A limitation on the heated water temperature reset provision is proposed to avoid imposing the requirement on very low temperature systems, which are expected to become more common with the use of heat pumps. Use of a reheat in these applications would be impractical.

New temperature reset requirements are proposed for condenser water, reflecting typical minimum practice.

Time switch provisions are proposed to be refined in line with refinements for time switches used in lighting controls.

Economy cycle provisions have been revised in line with cost-benefit analysis at the element level.

Mechanical ventilation controls

The existing provisions for mechanical ventilation controls have been clarified to include a requirement for energy reclaim systems to be fitted with a bypass when beneficial.

Fans and duct systems

The fan and duct system changes have aligned with the international standard (EU 327) for peak efficiency. There is also a dedicated provision dealing with the difference between selection efficiency and peak efficiency. In the current provisions, peak efficiency and selection efficiency were integrated into a single provision, reducing transparency.

These changes aim to streamline and simplify the provisions and discourage inappropriate applications of inefficient fan types in air-handlers.

Applications of variable speed operation have been broadened in line with current, cost-effective practice.

In response to feedback from code users, minimum pressure drops for some commonly used ductwork components, have now been specified. Provisions for maximum flexible ductwork length and minimum equivalent diameter for duct connection to fittings have also been clarified.

As per the current provisions, fan equipment can be assessed at the individual component level or system level. A process to allow for assessment at the building level is also proposed, i.e. across all air conditioning and ventilation fans. This improves flexibility and encourages a proportionate approach.

Ductwork insulation

An exemption for equipment complying with MEPS has been deleted. Feedback suggests the deleted provision was incorrectly interpreted as exempting ductwork connected downstream of the unit.

Pumps

The changes to the pump provisions are intended to broaden the application of variable volume systems and the use of variable speed drives for balancing. Variable volume operation is not required for pumps that serve primary heating or cooling plant only, as this equipment generally has very limited capability to vary the flow volume.

Pipework insulation

The proposed changes to the pipework insulation provisions remove an exemption for pipework insulation in equipment covered by MEPS. The MEPS test standard does not fully account for the heat loss through pipework that may be connected downstream of the equipment, as this will vary by application.

Refrigerant pipework has also been removed from the definition of 'heated fluids'. This reflects the experience of industry after the introduction of the NCC 2019 provisions, which found that the benefits from increasing the insulation requirements did not offset an increase in installation costs. As a result, refrigerant pipework insulation requirements are proposed to revert to the requirements of a cooling fluid, as per NCC 2016.

Space heating

The proposed changes for space heating introduce minimum efficiency requirements for heating systems that use heat pumps and allow greater use of direct electric heating. These proposals apply across all stringency levels and are consistent with the anticipated decarbonisation of the electricity grid. The heat pump stringency requirements are based on the market average because there was no strong relationship between efficiency and performance. Setting an average requirement based on the market average is not expected to unreasonably restrict supply.

Stringency Level 3 also includes measures that will facilitate future conversion of gas-powered equipment to electrically powered equipment.

Chillers

The chiller provisions have been revised based on cost-effectiveness considerations. The changes also stipulate chillers, which are connected to serve a common load, must be assessed as a system. This allows sizing practices to be taken into account in the assessment, allows greater flexibility for designers, and is a more proportionate approach.

Unitary air conditioning equipment

Minimum efficiency for air-cooled packaged air-conditioning systems (PACS) and variable refrigerant flow systems (VRF) are set on the basis of market averages (excluding the bottom quartile for VRF). While even higher stringencies were shown to be cost-effective, they are not proposed to be adopted due to the potential impacts on the availability of stock.

As with chillers, the changes also stipulate that air-cooled air conditioning unit efficiency should be assessed collectively.

Variable speed compressor and condenser fans are also proposed based on cost-effectiveness.

It is noted that this is a significant change in scope compared with the current provisions, which only cover units above 65 kWr.

There is also a correction to the reference standard AS/NZ 3823.1.2 to AS/NZ ISO 13256.1 for water-cooled unitary equipment, but there is no change to stringency levels for this equipment item.

Heat rejection equipment

Variable speed motors in heat rejection fans are proposed on the basis of cost-effectiveness.

Lighting

No overall increase in stringency is proposed for lighting illumination power densities. However, changes are proposed related to lighting switching and controls. The Lighting Council of Australia and the International Association of Lighting Designers were consulted during the development of these changes. The changes are designed to simplify the language of the provisions and update them so that they are consistent with new lighting control technologies.

In response to comment from the Australian Elevator Association, the maximum/illumination power density for lift car is proposed to be increased to 5 W/m^2 (refer to the last item in Table J7D3a). This value has been calculated on the basis of notes (1)(i) and (ii), (2) and (3) to Table J7D3a; Table J7D3b and Table J7D3c.

Electric Vehicles (EVs)

The installation of Type 2, 7 kW (32A) EV chargers is proposed for 15 per cent of carparking spaces in Class 3 and 9 buildings and for 10 per cent of carparking spaces in Class 5 and 6 buildings. These ratios reflect the projected need for EV chargers, given expected uptake of the technology, and because the power consumption of the equipment will be able to be met with business-as-usual electrical supply limits. The provisions also clarify how they are to be applied to accessible carparking spaces.

The main intent of these provisions is to increase the charging options for people unable to charge an EV at home, especially people living in existing Class 2 buildings where it is difficult to install EV charging equipment or Class 1 buildings without off-street parking. The proposed ratio of EV chargers is the same across all three stringency levels.

Renewable Energy

The technical analysis showed that maximising the amount of PV panels on available roof space was a cost-effective requirement for all building archetypes modelled. The strength of the business case for PV stems primarily from the opportunity to use the solar that is generated onsite to meet loads within the building, thereby reducing the amount of electricity that needs to be purchased from the grid. Under Stringency Level 2, the amount of PV required will depend on the amount of available unshaded roof space and the total energy building demand with the DTS Provisions designed to result in PV systems that export approximately 50 per cent of the energy produced.

Higher rates of PV installation would be required under Stringency Level 3, with a high proportion of PV being installed to meet the near net zero energy and GHG abatement requirement.

If a requirement for PV panels was adopted then the existing requirements in Part B for warehouse buildings to ensure that they have the appropriate structural capacity for them would be deleted, given PV would be being installed at the time of construction.

4 Approach to impact analysis

The impact analysis is conducted by comparing the impacts of proposed changes to the NCC (Options 1 to 3) to the baseline business as usual option (base case). The analysis aimed to identify likely impacts from the options through:

- early consultation with stakeholders from industry and government agencies;
- reviewing energy modelling results by DeltaQ; and
- reviewing relevant data from other sources to assist the analysis.

Overview of impact analysis methodology

Early consultation with stakeholders

The purpose of the targeted early consultations was to gather relevant views and information necessary to complete the cost-benefit analysis (CBA), especially the key parameters that likely affect the CBA.

A range of stakeholders covering the major commercial building sectors were contacted to seek their views on potential implications from the proposed changes to Section J of NCC. To assist the consultation, an issues paper including questionnaires was prepared and sent to stakeholders before the interview.

Findings from the consultation are discussed in the relevant parts of this chapter.

Review of DeltaQ modelling

DeltaQ has conducted whole-building modelling of the impacts of the proposed changes to the NCC on energy consumption by fuel type (electricity and gas) as well as electricity exported to the grid (for stringencies where rooftop solar is mandatory). DeltaQ's modelling compares buildings compliant with NCC 2019 and NCC 2025 (under all stringencies) across:

- 10 building archetypes (see appendix E for further details), including:
  - a small hotel (Class 3)
  - a large hotel (Class 3)
  - a small office building (Class 5)
  - a medium office building (Class 5)
  - a large office building (Class 5)
  - a strip retail building (Class 6)

  - a large shopping centre (Class 6)
  - a large hospital ward (Class 9a)
  - a school (Class 9b)
  - an aged care facility (Class 9c)
- each of the 8 climate zones.

Cost-benefit analysis

The cost and benefit estimates are broadly based on DeltaQ modelling at the building level. For a range of building archetypes (see appendix E for further details) across all 8 climate zones, DeltaQ has modelled the impact of the proposed changes to the code using the DTS pathway, including the impact on:

- energy consumed from the grid (including electricity and gas);
- export of excess energy generated on-site; and
- capital-related costs.

Building level costs and benefits are aggregated up to the climate zone, state and national level using construction projections for each building type by state.

Presentation of CBA results

The main measures typically used to summarise the results of a CBA are:

- Net present value (NPV) — this measure subtracts the 'present value' of the estimated stream of future costs from the present value of the estimated stream of future benefits, where future costs and benefits are discounted back to a common year.
  - An NPV greater than zero (i.e. the NPV is positive) indicates that the present value of the benefits outweigh the present value of the future costs (i.e. the proposal delivers a net benefit to the community).
  - An NPV less than zero (i.e. the NPV is negative) indicates that the present value of future costs outweighs the present value of future benefits (i.e. the proposal delivers a net cost to the community).
- Benefit-cost ratio (BCR) — this measure is the present value of the estimated stream of future benefits divided by the present value of the stream of future costs.
  - A BCR greater than 1 indicates the present value of the benefits outweigh the present value of the future costs (i.e. the proposal delivers a net benefit to the community).
  - A BCR less than 1 indicates the present value of the future costs outweighs the present value of the future benefits (i.e. the proposal delivers a net cost to the community).

For the purposes of the CRIS, we focus on the NPV measure. In the context of measures to improve energy efficiency, the BCR would typically compare the benefits associated with reduced future energy consumption with the additional capital-related costs. However, based on DeltaQ's estimates, the capital-related costs associated with complying with NCC 2025 are actually lower than for NCC 2022 (see further discussion below) for Stringency Level 1 (i.e. there are no measurable costs). In this context, the BCR is not a meaningful measure.

CBA parameters

Time period

RISs typically use a five- or ten-year time horizon for measuring the costs and benefits. However, buildings are typically long-lived assets, with a life of 40 or more years. Following the paper by Hutley (2023) who has investigated the literature on commercial building lifecycle,[83] we will assume a building life of 50 years with 40 years and 60 years for the sensitivity analysis.

For building services, the life is around 20 years, according to DeltaQ. The life of services will be extended to be the same as the life of building, meaning replacement costs will be considered.

Following the previous RISs, we conduct the analysis of costs over a ten-year period but include in the benefits the full life of each building/services constructed or installed during that ten-year regulatory period.

Discount rate

The nature of investments in energy efficiency (i.e. upfront costs in exchange for a stream of future benefits) and the long timeframes involved mean that energy efficiency CBAs are particularly sensitive to the discount rate.

The OIA typically requires a real discount rate of 7 per cent to be used in a RIS, with sensitivity analysis using 3 per cent and 10 per cent. This is intended to reflect the social discount rate.

However, there is a case for deviating from the OIA's preferred 7 per cent in this context. As for analysis conducted over periods longer than 30 years, OIA suggests using lower discount rates. In particular, for analyses over 31-75 years, OIA recommends using a discount rate of 5.4 per cent.[84]

It is recommended a central case discount rate of 5 per cent,[85] accompanied by 2 per cent and 7 per cent as the sensitivity analysis rates, based on the practice in some jurisdictions and the long-timeframe impact. OIA agreed to the alternative discount

83 Hutley, N. 2023, *Economic parameters for technical work (NCC)*, report for Australian Building Construction Board, Rovingstone Advisory Pty Ltd, p. 4.

84 Australian Government Office of Best Practice Regulation, *Environmental Valuation and Uncertainty*, Guidance Note, July 2014, p. 4.

85 Hutley (2023), op. cit., p.6.

rates for this project. Hence, these specified discount rates will be used for conducting the cost-benefit analysis.

Establishing a base case

A key element of cost-benefit analysis is establishing a credible base case (which is generally defined as the scenario that would apply without the regulatory proposal) against which the benefits and costs of various options are assessed. The base case for this study is the status quo (or 'business as usual').

Business as usual implies Section J of the NCC to remain as it currently applies. In addition, the base case should incorporate any existing policy measures that affect the energy efficiency decisions in relation to commercial buildings. It should also incorporate any foreseeable new policies that would be implemented regardless of whether the proposed changes to the NCC are implemented.

The base case should also incorporate currently and future available technology for energy efficiency. This will be discussed in more detail below.

Impacts of more stringent minimum energy efficiency standards

The main impacts of changes in the stringency of the minimum energy efficiency standards could include:

- changes in construction costs
- changes in the building design
- energy savings during the building's operation phase, and
- GHG emission reduction as a consequence of changing energy consumption and fuel mix (electricity and gas).

Energy efficiency under the base case

It is important that the voluntary uptake of energy efficiency over and above existing NCC requirements is included in the base case. As outlined above, if voluntary uptake of higher levels of energy efficiency than is required under the current code is not included in the base case, the CBA will overstate the impact of the regulatory change on energy consumption.

As there are no comprehensive sources of data on the energy efficiency features of commercial buildings, establishing a credible base case is a challenge. Stakeholder feedback on the base case in relation to energy efficiency standards included the following:

- Several stakeholders noted that in general, very few (if any), buildings voluntarily exceed the minimum standards set out in the current code.
- Others noted that some premium CBD offices may choose to exceed minimum standards, but it is unlikely outside this segment of the market.

- Some stakeholders noted that the use of performance solutions to comply with Section J is common, but this is mostly to make trade-offs across different building elements, rather than to exceed the minimum standards. This means that some buildings may exceed the minimum DTS requirements for some elements, but not overall.

Based on this qualitative evidence, we assume that no voluntary exceedance of the existing code is a broadly reasonable base case.

That said, it is important to carefully scrutinise whether there is a plausible reason why any elements of the proposed changes that are both cheaper to implement and are more energy efficient (or have very high benefit-cost ratios) are not being implemented voluntarily.

Change in capital costs

In general, higher capital costs are associated with higher stringency requirements for energy efficiency. Nevertheless, preliminary modelling indicates that enhancing the performance of the building envelope can potentially reduce the size of HVAC systems. This reduction can lead to a net reduction in overall construction or capital costs, wherein the higher cost for a more efficient envelope is more than offset by the reduced cost associated with HVAC equipment.

However, it is worth noting that stakeholder consultations have highlighted a common practice in HVAC system design which tends to be conservative. This means that the theoretically projected reduction in HVAC size may not always be fully realised in practice.

In some circumstances, more stringent energy efficiency requirements may result in design comprises. For example, more stringent façade requirements may mean in some cases it is not possible to achieve compliance with the proposed NCC requirements using the DTS pathway without reducing the window size, installing external shading, or pursuing a Performance Solution pathway for compliance. To the extent that these design compromises have a material impact on aesthetic/amenity values, this would normally be considered a cost in economic analysis. These hidden costs may need to be considered.

Learning rates

Some analyses of energy efficiency policy changes (such as changes to minimum standards) include a 'learning rate'.[86] Conceptually, the learning rate reflects how quickly firms adapt and adopt new technologies and techniques, and revise their designs and/or production processes.[87] The premise is that raising the Performance

86 See for example: DeltaQ and Strategy.Policy.Research. 2022, *Commercial Buildings Low-Energy Trajectory*, NCC 2025 Update to Achieving Low Energy Commercial Buildings in Australia, Final Report, 10 March 2022, p. 68.

87 pitt&sherry 2016, *Commercial Building Learning Rates*, Final Report, Prepared for the Department of Industry, Innovation and Science, 3 August 2016, p. ii.

Requirements in the NCC may initially increase costs; however, these additional costs will decline over time as the industry adapts (or learns).

The main ways through which the incremental costs associated with higher performance requirements could decline over time are:

- declining input prices — the price of new technologies can sometimes decline rapidly initially (due to economies of scale resulting from rapid adoption) before levelling off;
- construction techniques and supply chain maturity; and
- innovation and learning in relation to design.

Stakeholders have confirmed that the learning rate is dependent on the maturity of technology. Most of the technologies are now relatively mature, meaning they are not in the rapid learning phase.

The technical consultant, DeltaQ, investigated learning rates for specific technologies, such as roof-top PV and heat pumps, and finds no hard evidence to support or justify a specific learning rate.

Learning rates are therefore not included in the central analysis. However, learning rates have been considered in the sensitivity analysis following the advice from the independent economic adviser.

Energy savings

The primary data of energy savings is from DeltaQ's energy modelling at the building level. The modelling provides hourly energy consumption for the base case (NCC 2022) and the proposed NCC 2025 options.

We use the retail price approach to value energy savings. In particular we estimate the time of use (ToU) price including wholesale prices, network usage/consumption charges and capacity charges and retail margins, based on historical data, distributor tariff data and Australian Energy Market Operator (AEMO) price projections. Appendix B provides more details on the energy price estimates.

Are modelled energy saving realised?

Although the issue remains poorly understood, there is some recent evidence to suggest that modelled energy savings are often not realised in practice (see appendix C for details). In particular:

- A report for the International Partnership for Energy Efficiency Cooperation (IPEEC) Building Energy Efficiency Taskgroup (BEET) noted increasing evidence of expected savings from retrofit projects not being realised.[88]
- Recent data from the Green Building Council of Australia (GBCA) suggests that:

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88 International Partnership for Energy Efficiency Cooperation (IPEEC) Building Energy Efficiency Taskgroup 2019, *Building Energy Performance Gap Issues: An International Review*, p. 14.

  - less energy efficient buildings are more likely to over-perform relative to the modelled performance;
  - more energy efficient buildings are more likely to under-perform relative to the modelled performance.

However, a recent scoping study investigating the Building Energy Performance Gap (BEPG) found that:

- it is not appropriate to extrapolate from findings in relation to the performance gap based on the GBCA's 2021 dataset to other building types for the purposes of regulatory impact analysis.[89]
- the performance gap in other types of buildings that are not captured by these rating systems remains unquantified and poorly understood.
- there is no data currently available within industry that could be aggregated to create an appropriate dataset.[90]

Based on these findings it seems unlikely that a robust estimate of the extent to which modelled energy savings associated with more stringent energy efficiency standards will be realised in practice will be available in the short term. As a result, the central case in the cost-benefit analysis of this CRIS uses the full realisation scenario with lower realisation scenarios (50 per cent and 75 per cent realisation) being included in the sensitivity analysis.

Greenhouse gas emissions reductions

Reducing consumption of energy generated through burning fossil fuels through improved energy efficiency will reduce GHG emissions that contribute to climate change.

The paper by Hutley (2023) has recommended emissions intensity parameters for electricity (scopes 2 and 3 combined, chart 4.1) and natural gas (scopes 1 and 3, table 4.2).[91]

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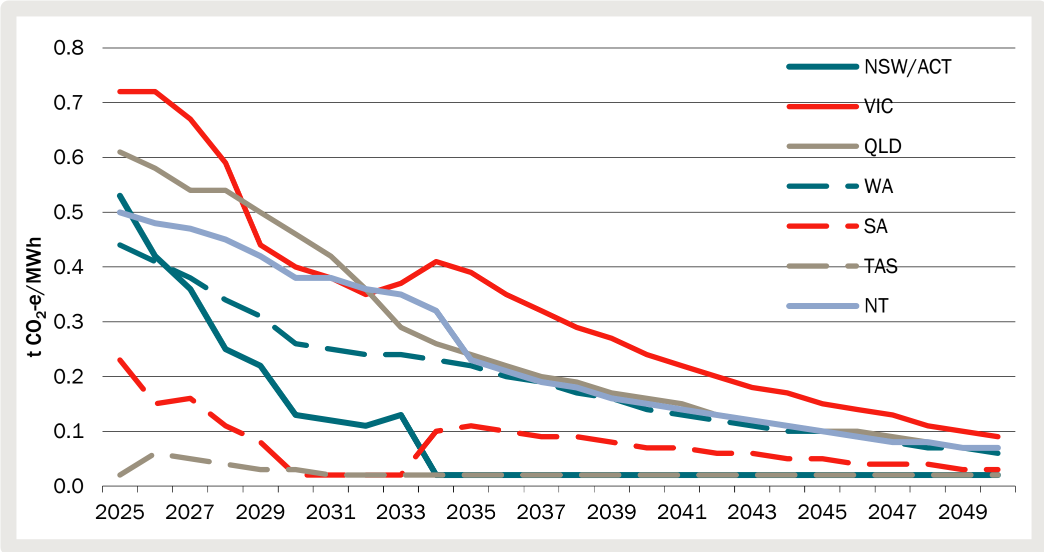
89 Green Building Council of Australia 2022, *Building Energy Performance Gap NCC 2025 — Scoping Study*, August 2022, pp. 5-6.

90 Green Building Council of Australia (2022), op. cit., p. 7.

91 Hutley, N. 2023, *Economic parameters for technical work (NCC)*, Rovingstone Advisory Pty Ltd, February 2023, Tables 5.2, 5.3, 5.5 and 5.6.

4.1 Indirect scope 2 and 3 combined emissions factors of electricity consumption



Data source: Hutley (2023), Table 5.2 and Table 5.3

4.2 Natural gas emissions factors

Scope	NSW (Kg CO2-e/GJ)	VI (Kg CO2-e/GJ)C	QLD (Kg CO2-e/GJ)	WA (Kg CO2-e/GJ)	SA (Kg CO2-e/GJ)	TAS (Kg CO2-e/GJ)	ACT (Kg CO2-e/GJ)	NT (Kg CO2-e/GJ)
Scope 1	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5
Scope 3	13.1	4.0	8.8	10.7	4.1	4.0	12.8	4.1
Total	**64.6**	**55.5**	**60.3**	**62.2**	**55.6**	**55.5**	**64.3**	**55.6**

Source: CIE based on Hutley (2023), Table 5.6.

The emissions intensity factors for electricity consumption up to 2035 are adopted from DCCEEW projections[92] which incorporate the legislated 43 per cent emissions reduction target for 2030 (from a 2005 baseline).[93] For projections beyond 2035, the paper by Hutley (2023) has taken consideration of the trend of the Step Change scenario in AEMO's 2022 Integrated System Plan (ISP)[94] and assumes the intensity factor will continue to decline by 10 per cent per annum at a national average level (which is consistent with the average 10 per cent rate of decline projected to 2035) to levels broadly consistent with Net Zero.[95]

For gas emissions factors (table 4.2), the independent advisor has adopted the factors published by DCCEEW (2022).

92 DCCEEW 2022, *Australia's emissions projections 2022*, Department of Climate Change, Energy, the Environment and Water, Canberra.

93 Hutley (2023), op. cit.

94 AEMO 2022, *2022 Integrated System Plan*, June 2022, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

95 Hutley (2023), op. cit.

We use these parameters to estimate the reduction in GHG emissions based on the DeltaQ energy modelling results.

As for valuing the benefits of reducing GHG emissions, there are also various approaches including:

- A market or shadow carbon price — in principle, an economy-wide carbon price should reflect the marginal cost of abatement. However, as there is effectively no economy-wide carbon price in Australia,[96] approaches have included:
  - carbon prices that apply in other markets (such as the EU),
  - a modelled carbon price to reach emissions reduction target (such as net zero by 2035).
- The social cost of carbon (SCC) approach, such as the SCC series published by the United States Environment Protection Agency (USEPA)[97].

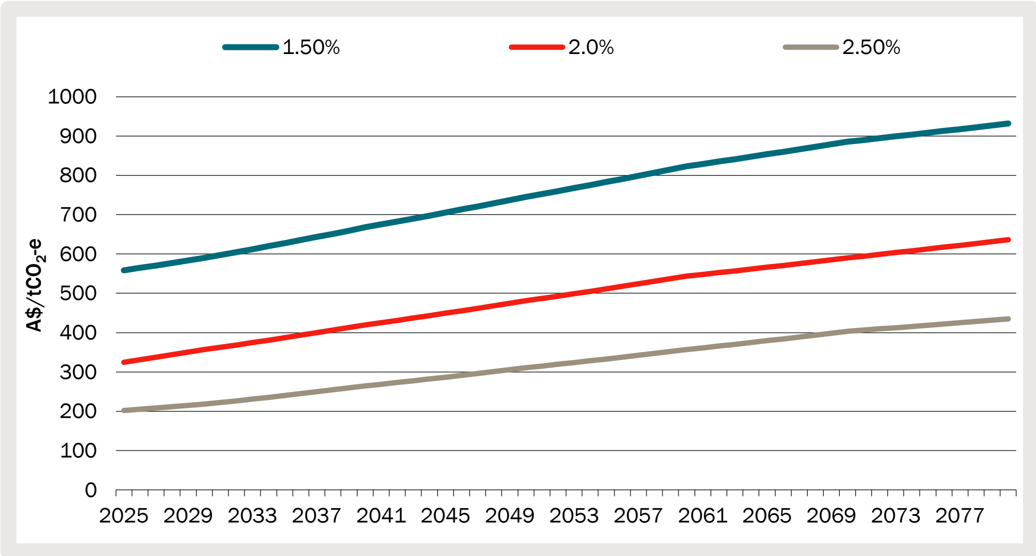
We follow the recommendation in the paper by Hutley (2023) to use SCC published by USEPA (converted to 2023 Australian dollar) for valuation of GHG emissions reduction.[98] Chart 4.3 presents three SCC series, among which the 2 per cent series is used in the central case cost-benefit analysis while the other two series are used for sensitivity analysis.

96 Australian Carbon Credit Units (ACCUs) are issued by the Clean Energy Regulator for greenhouse gas abatement activities undertaken as part of the Australian Government's Emissions Reduction Fund. An ACCU represents one tonne of carbon dioxide equivalent stored or avoided by an 'eligible offsets project'. Because the scheme does not cover all abatement activities, such as abatement in the electricity sector is not covered, it does not represent a comprehensive measure of nationwide abatement, let alone establish an economy-wide carbon price. The spot generic ACCU price is about $38 per unit (Clean Energy Regulator, '1. Australian carbon credit units (ACCUs)', Australian Government, 2023, https://www.cleanenergyregulator.gov.au/Infohub/Markets/Pages/qcmr/march-quarter-2023/Australian-Carbon-Credit-Units.aspx, accessed 3 November 2023).

97 USEPA 2023, *EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances*, p.4, https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

98 Hutley (2023), op. cit., Table 4.4, p.12.

4.3 Social cost of carbon



Data source: CIE estimates based on USEPA (2023).

Restrictions on design choices

The proposed changes to the NCC will restrict design choices in several ways, including the following:

- The windows on some buildings will need to be tinted (i.e. have lower visual light transmittance) to achieve compliance with the proposed requirements — although this will still allow an adequate level of daylighting (daylighting requirements are not specified in the NCC), this will be less than what is current practice.
- The maximum window to wall ratio (WWR) that will be achievable without external shading will be reduced from 70 per cent (under NCC 2022) to 58 per cent — although this will not affect most building archetypes (as the WWR for most buildings is lower than this threshold), this will have some impact, particularly on large office buildings where extensive glazing is relatively common.
  - Note that DeltaQ's modelling assumes the same WWR under the base case and under all stringencies and does not include the cost of shading. This is because the archetypes are intended to reflect a 'representative' building based on the average WWR within the building class. Previous work estimated the average WWR for an office tower is around the maximum threshold achievable without shading (around 58 per cent).
  - This means that the proposed requirements will not affect the 'average' office tower and therefore these effects are not reflected in the modelling.
  - However, around half of office towers will have higher WWRs than average and would be affected by this restriction and would need to either install external shading (which can be expensive) or reduce the WWR.

- As the minimum standards have been tightened across all building elements there will be fewer opportunities to make trade-offs across elements (including through the use of Performance Solutions) to achieve particular design outcomes.

These restrictions on design choice will impose costs that are hard to measure, which could include the following:

- Loss of aesthetic or amenity value — where design compromises have been made, there may be a loss of aesthetic or amenity value. Although these values are subjective, in principle, design compromises that change either the external appearance or the internal aesthetics for building users is likely to impose a cost on the community.
  - There are no identifiable market failures that would lead building owners and designers to make design choices that are systematically sub-optimal from a communitywide perspective in relation to building aesthetics/amenity (although there are some market and behavioural failures in relation to energy efficiency choices — see appendix A).
  - In the absence of identifiable market failures, a standard assumption in economic analysis is that market participants will make design choices that achieve the optimal combination of cost and building aesthetic/amenity value, particularly where these values are reflected in the market value of the building and/or rents.
  - To the extent that these aesthetic/amenity values are reflected in the market value of these buildings and/or rents, these benefits could in-principle be measured. However, there is no publicly available data that would allow these values to be estimated.
- Additional financial costs — where building owners and their design teams choose to achieve their preferred design outcome through the use of external shading, they will incur an additional financial cost.
  - Although the costs of external shading have not been explicitly modelled, we understand that external shading is costly and likely to outweigh the benefits of greater energy efficiency.
  - The choice to incur the financial costs associated external shading would indicate a strong preference for the relevant design features (i.e. extensive glazing and/or glazing with high visual light transmittance).

Increased rental income and building values

Numerous studies, including Australian studies, have shown that more energy efficient buildings achieve higher rental income (either through higher lease rates or occupancy rates) and sale prices.[99]

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[99] See for example, Newell, G. MacFarlane, J. and Kok, N. 2011, *Building Better Returns: A Study of the Financial Performance of Green Office Buildings in Australia*, September 2011.
Knight Frank 2022, *Active Capital: Trends in Global Real Estate Investment*, https://content.knightfrank.com/research/1801/documents/en/active-capital-the-report-2021-8447.pdf

Higher rental income and building value would reflect higher demand from tenants for higher rated buildings (relative to lower rated buildings). Tenants are willing to pay more for higher rated buildings due to a combination of factors including:

- lower energy bills (included in outgoings);
- a preference for 'greener buildings' to meet environmental, social and governance (ESG) objectives;
- a perception that higher-rated buildings are of superior quality (in terms of building management or other characteristics).

The benefits of lower energy bills and reduced GHG emissions will be measured directly in the CBA (see above), so increased rental incomes and building values should not be included separately in the CBA as this would involve double-counting these benefits.

Broader economic impacts

Some studies refer to a range of broader economic impacts, including industry productivity improvements and the flow-on economic impacts of increased investment in energy efficiency and reduced energy consumption.[100]

These flow-on economic impacts are outside the scope of the partial equilibrium framework typically used for RISs. Only benefits that are additional to the energy savings identified above should be included, for example, productivity gains due to improved thermal comfort (see below section on health).

Health, productivity and societal benefits

Health benefits from reduced coal-fired electricity

There are health benefits arising from the improved energy efficiency that reduces energy consumption generated from fossil fuels. Power stations, especially coal-fired power stations, emit a range of toxic pollutants and are the key sources of generating sulphur dioxide, oxides of nitrogen and fine particle pollution (PM2.5). Exposure to such toxic pollutants has a health burden and may cause premature deaths, heart attacks, strokes, asthma attacks, low birth weight infants, lung cancer and type 2 diabetes.[101] Reducing the consumption of energy that involves burning of fossil fuels

100 See for example: International Energy Agency (IEA), 2014, *Capturing the Multiple Benefits of Energy Efficiency*, pp. 45-66.

101 Environmental Justice Australia, 'The health burden of coal-fired power in NSW', 2023, https://envirojustice.org.au/legal-work/ending-pollution/the-burden-of-coal-fired-power-in-nsw/, accessed 5 December 2023.

(particularly coal-fired electricity generation) can therefore reduce the health burden.[102]

There is literature estimating health impacts in terms of damage cost per megawatt hour (table 4.4). The cost assessment is often locally specific to metropolitan regions, depending on a range of factors such as local context, electricity generation models and outlooks in the region and the state, the volume and nature of the emissions of the relevant pollutants, how those pollutants are dispersed, and population exposure in the relevant areas.

4.4 Health cost of coal power stations in 2023 dollar

Source	Region	Pollutant	Damage cost (A$/MWh)
M Mazaheri et al. 2021	NSW Greater Metropolitan Area	PM2.5	2.93
CIE 2020	VIC	SO_2, NO_x, PM2.5, PM10	14.26 – 22.56
CIE 2019	Urban areas where coal power stations are located	PM2.5	0.0 - 0.52

Source: M Mazaheri et al., 'Monetising Air Pollution Benefits of Clean Energy Requires Locally Specific Information', in *Energies*, vol. 14, 2021, 7622. CIE, *Greenhouse gas emissions projections and economic analysis of emissions reduction in Victoria - Whole of the economy modelling*, Prepared for the Department of Environment, Land, Water and Planning, 2020, unpublished. CIE, *Independent review of the Commercial Building Disclosure Program*, Prepared for the Department of the Environment and Energy, 2019, https://www.cbd.gov.au/sites/default/files/2020-09/cbd_review_cie_report_draft.pdf.

Mazaheri et al. (2021) estimated the health damage attributable to long-term exposure to PM2.5 concentrations for the NSW greater metropolitan area which cover over 85 per cent of the NSW population.[103] The health cost per megawatt hour was estimated at $2.40 in 2016 dollar (equivalent to $2.93 in 2023 dollar). It was drawn upon the estimated life years gained in reducing long-term exposure to PM2.5 through clean energy program, under the medium demand shock scenario throughout 2026-2118 (covering the entire period until extinction of the population cohort) using a real social discount factor of 7 per cent. The estimate accounts for dispersion of PM2.5 within the NSW greater metropolitan area and is specific to NSW where coal power stations primarily use black coal.

CIE estimated the health cost per megawatt hour of electricity generated by the VIC coal power stations (using brown coal) based on estimates from J Ward & M Power (2015).[104] The health damage is attributable to long-term exposure to sulphur

102 Bertrand, S. 2021, *Fact Sheet - Climate, Environmental, and Health Impacts of Fossil Fuels* , Environmental and Energy Study Institute, 17 December 2021, https://www.eesi.org/papers/view/fact-sheet-climate-environmental-and-health-impacts-of-fossil-fuels-2021, accessed 3 November 2023

103 Mazaheri, M., Y. Scorgie, R.A. Broome, G.G. Morgan, B. Jalaludin and M.L. Riley 2021, 'Monetising Air Pollution Benefits of Clean Energy Requires Locally Specific Information', *Energies*, vol. 14(22), 7622, November.

104 Centre for International Economics (CIE) 2020, *Greenhouse gas emissions projections and economic analysis of emissions reduction in Victoria: Whole of the economy modelling*, report to the Department of Environment, Land, Water and Planning, September 2020.

dioxide, oxides of nitrogen, PM2.5 and PM10.[105] Table 4.2 reproduces these estimates in 2023 terms. The estimates considered dispersion and transformation of pollutants using air plume modelling and represent a shadow market value of the health impacts of using willingness-to-pay methodology.

4.5 Health cost per unit of generation for Victorian power stations in 2023 dollar

Power station	Damage cost (A$/MWh)
Hazelwood	10.10
Loy Yang A	22.56
Loy Yang B	20.17
Yallourn	14.26

Source: DELWP, *Estimating the health costs of air pollution in Victoria*, DELWP Economics working paper to inform the Independent Expert Panel on Interim Targets, 2018, table 2, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0022/421717/Final_Health-costs-of-air-pollution-in-Victoria.pdf, accessed 6 December 2023.

CIE further estimated future local health impact with the changes in population density and local family income, which translate to projected population growth in the local region and projected gross state product (GSP) growth as an important factor of the future willingness to pay.[106]

CIE had also estimated heath costs associated with operating coal power stations for NCC 2019 (table 4.6).[107] The estimates are health damage attributable to exposure to PM2.5 in the urban areas where the stations are located or nearby, but they did not account for dispersion of pollutants.

Ward, J. and M. Power 2015, *Cleaning up Victoria's Power Sector: the full social cost of Hazelwood power station*, report to Environment Victoria.

105 DELWP, *Estimating the health costs of air pollution in Victoria*, DELWP Economics working paper to inform the Independent Expert Panel on Interim Targets, 2018, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0022/421717/Final_Health-costs-of-air-pollution-in-Victoria.pdf, accessed 6 December 2023.

106 J Ward & M Power (2015) identified two major determinant of local impacts – stack height and local population density. It is understood that there will be no new coal power stations in Victoria, and the stack heights of current stations will remain the same over the period to their closure. It is therefore appropriate to consider population density will estimate unit costs beyond 2018.

107 CIE 2019, *Independent review of the Commercial Building Disclosure Program*, report to the Department of the Environment and Energy, September 2019, https://www.cbd.gov.au/sites/default/files/2020-09/cbd_review_cie_report_draft.pdf

4.6 Health cost by facility in 2023 dollars

Facility Name	Urban area (nearest)	Emissions intensity ($tPM_{2.5}$/ GWh)	Damage cost ($/$tPM_{2.5}$)	Damage cost (A$/MWh)
Eraring Power Station (NSW)	Morisset - Cooranbong	0.005	25 735	**0.12**
Bayswater Power Station (NSW)	Muswellbrook	0.006	18 717	**0.12**
Liddell Power Station (NSW)	Muswellbrook	0.029	18 717	**0.55**
Vales Point Power Station (NSW)	Central Coast	0.012	214 071	**2.53**
Mt Piper Power Station (NSW)	Lithgow	0.021	40 943	**0.86**
Tarong Power Stations (QLD)	NIASUA (QLD)	0.141	175	**0.02**
Gladstone Power Station (QLD)	Gladstone - Tannum Sands	0.019	70 187	**1.37**
Stanwell Power Station (QLD)	Rockhampton	0.018	51 471	**0.94**
Millmerran Power Station (facility) (QLD)	Toowoomba	0.061	85 395	**5.20**
Callide C Power Station (QLD)	NIASUA (QLD)	0.050	175	**0.01**
Callide B Power Station (QLD)	NIASUA (QLD)	0.070	175	**0.01**
Kogan Creek Power Station (QLD)	NIASUA (QLD)	0.005	175	**0.00**
Loy Yang Power Station and Mine (VIC)	Traralgon - Morwell	0.050	66 678	**3.33**
Yallourn Power Station (VIC)	Traralgon - Morwell	0.070	66 678	**4.67**
Loy Yang B Power Station (VIC)	Traralgon - Morwell	0.030	66 678	**1.99**
Muja Power Station (WA)	NIASUA (WA)	0.054	5	**0.00**
Collie Power Station (WA)	NIASUA (WA)	0.135	5	**0.00**
Bluewaters Power Station No 1&2 (WA)	NIASUA (WA)	0.004	5	**0.00**

Source: CIE update based on CIE, *Independent review of the Commercial Building Disclosure Program*, Prepared for the Department of the Environment and Energy, 2019, <https://www.cbd.gov.au/sites/default/files/2020-09/cbd_review_cie_report_draft.pdf>. The table is based on information sourced from PAEHolmes, 2013, Methodology for valuing the health impacts of changes in particle emissions - final report. For NSW Environment Protection Authority (EPA); *Clean Energy Regulator, 2019, Electricity sector emissions and generation data 2021-22*; Australian Department of the Environment and Energy, *Latest NPI emissions for 2017-2018, http://www.npi.gov.au/npi-data/latest-data* CIE, *Independent review of the Commercial Building Disclosure Program*, Prepared for the Department of the Environment and Energy, 2019, <https://www.cbd.gov.au/sites/default/files/2020-09/cbd_review_cie_report_draft.pdf>.

Whilst we have sought to establish a health burden assessment for coal-fired electricity generation, at this stage we have not included these impacts into the cost-benefit analysis with the following reasons.

- The health cost appears to be small. A damage cost of $10 per MWh is equivalent to 1 cent per kWh. This is relatively small compared to other benefits through improved energy efficiency. In addition, the estimate is regionally constrained or pollutant specific, and estimates at aggregate level are dependent on assumptions and generally interpreted as an indicator of potential health impacts.
- It is difficult to link the reduction in energy consumption via energy efficiency improvements from specific buildings to particular coal fire stations and thus to provide a robust estimate.
- Along with the grid's decarbonisation and expected closure schedule of several coal power stations in the next 10 years, the health impacts stemming from particle pollution are expected to decrease.

  – Eraring Power Station will be decommissioned in New South Wales in August 2025 and Yallourn Power Station in Victoria in 2028.
  – The currently announced closure timings suggest that 8.4 GW of the current 23 GW of coal capacity will withdraw by 2030. In AEMO's Step Change scenario, modelling indicates 14 GW of coal-fired generation is likely to withdraw by 2030 to meet tighter carbon budgets for the sector. All coal capacity could close as early as 2040.[108]

Health and productivity benefits

Any health and productivity benefits would be in addition to the energy benefits estimated above. There is literature that investigates the relationship between energy efficient measures and perceptions of wellbeing and/or work performance amongst building occupants, especially the impacts of energy efficient solutions in office buildings on office users. Nevertheless, literature has showed varied perceptions of comfort, wellbeing and productivity in response to the energy efficient offices (box 4.7). In general, there appears some correlations between energy efficiency and improved health and performance outcomes, but they are not proof of causal relationships.

4.7 Literature on the impacts of energy efficiency on health and productivity

Steinemann, Wargocki and Rismanchi (2017) examined empirical evidence on whether energy efficient buildings may promote health outcomes of occupants through better indoor air quality (IAQ) and found that perceived IAQ is higher in energy efficient buildings than in comparable conventional buildings. However, in most studies no measurements were performed in parallel to subjective evaluations to explore true differences in pollutant exposure between the investigated buildings. In addition, the perception of better IAQ can be attributed partly to overall high satisfaction of working in a green building, which may propagate on satisfaction with IAQ. While the health outcomes are improved in energy efficient buildings, as perceived by occupants, no sufficient connection is made between the subjective results and objective measurements of exposure.

Wallner et al. (2017) carried out a quasi-experimental field study to investigate differences in self-rated health status between occupants in energy efficient buildings with mechanical ventilation (test group) and those with natural ventilation (control group). Occupants in the test group rated the overall health status of their own and children not significantly higher than occupants in the control group. Adult occupants in the test group reported dry eyes statistically significantly more frequently, compared to the control group. In addition,

108 AEMO, *2022 Integrated System Plan*, 2022, p. 49, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf, accessed 11 December 2023

mechanically ventilated buildings have better self-rated IQA and climate than naturally ventilated buildings.

Kozusznik et al. (2019) conducted a systematic review to identify existing empirical evidence on the relationships between energy efficient solutions in sustainable office buildings and the perceptions of employees' wellbeing and productivity, as well as the boundary conditions for these relationships to occur. Among the 19 reviewed studies, 9 of them reported significant positive relationship between energy efficient buildings and perceived wellbeing and productivity of occupants. 7 studies reported insignificant positive relationships, and 2 studies found significant negative relationships. 1 study found neutral impact of energy efficient buildings on occupants' health outcomes. These reviewed studies have different research designs, and the diversity of their results suggest study design is an important factor. That being said, the majority of reviewed studies show positive correlation between energy efficient measures and perceived health outcomes and/or work performance. In addition, some studies pointed out some moderators in the relationship such as degree of occupants' control over the office environment, users' adaptive behaviours, effective training provision in high-performing green buildings and the use of private workspaces.

Menadue, Soebarto and Williamson (2014) carried out a comparative post-occupancy internal environment monitoring and occupant survey on buildings with and without Green Star certification in Australia. Green-rated buildings exhibit equal and, in some circumstances, decreased occupant satisfaction of internal thermal conditions, compared to non-green-rated buildings.

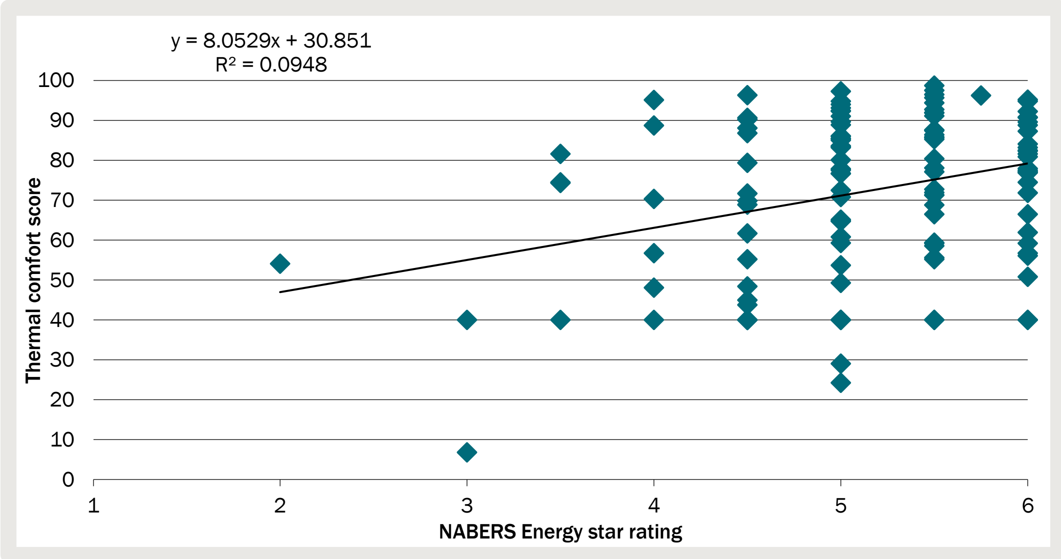
Source: MW Kozusznik et al., 'Decoupling Office Energy Efficiency From Employees' Well-Being and Performance: A Systematic Review', in *Frontiers in Psychology*, vol. 10, 2019. V Menadue, V Soebarto & T Williamson, 'Perceived and actual thermal conditions: case studies of green-rated and conventional office buildings in the City of Adelaide', in *Architectural Science Review*, vol. 57, 2014, 303–319. A Steinemann, P Wargocki & B Rismanchi, 'Ten questions concerning green buildings and indoor air quality', in *Building and Environment*, vol. 112, 2017, 351–358. P Wallner et al., 'Health and Wellbeing of Occupants in Highly Energy Efficient Buildings: A Field Study', in *International Journal of Environmental Research and Public Health*, vol. 14, 2017, 314.

In the 2015 review of the CBD program, ACIL-Allen Consulting found significant productivity benefits of the CBD program even under conservation assumptions. That said, these benefits were reported separately from the main CBA results due to a lack of sufficient data estimating the productivity benefits of energy efficient buildings as well as the high degree of uncertainty in estimation.[109]

In addition, drawn upon the NABERS database, an analysis of the NABERS Energy rating and the NABERS Indoor Environment Quality (IEQ) rating suggests a weak relationship between the NABERS Energy rating and the thermal comfort score (a key component of IEQ that is most likely to be associated with energy efficiency) (chart 4.8).

109 ACIL-Allen Consulting 2015, *Commercial Building Disclosure: Program Review*, Department of Industry and Science, 2015, pp. 56-57.

4.8 Relationship between NABERS energy rating and thermal comfort score



Data source: CIE based on NABERS database.

One caveat here is that there are few buildings with a NABERS Energy rating of less than 4 stars in the dataset. This implies that the weak relationship may be more relevant to the higher-rated buildings rather than lower-rated buildings. There is some evidence to suggest that for low-rated buildings, improvements in the NABERS Energy star rating are associated with increased thermal comfort.[110]

Furthermore, the NABERS IEQ tool has two thermal comfort methodologies. One of these methodologies is only available to buildings with annual tracking and storing of temperature data. The thermal comfort score may be artificially low for buildings that do not store their annual temperature data. This may partly explain the weak relationship between the NABERS Energy rating and the thermal comfort score.

As there is no conclusive and robust evidence to show a link between energy efficiency and thermal comfort, we have not included the benefits any health and productivity improvements associated with IEQ in the CBA.

Impacts of mandatory rooftop solar requirements

Under Stringency Level 2, installation of rooftop solar would be mandatory for commercial buildings.

110 In the Window Film Secondary Glazing Retrofit Trials in Victoria (2017), it is noted that applying the film to existing windows in the living areas of houses resulted in better thermal comfort, increasing from an average energy rating of 3.1 to 3.6 starts. See P Rajagopalan et al., *Enhancing home thermal efficiency. Final report of Opportunity Assessment for Enhancing home thermal efficiency*, RACE for 2030 Cooperative Research Centre, May 2023, p. 132, https://racefor2030.com.au/wp-content/uploads/2023/05/H2-OA-0199-Final-Report_.pdf, accessed 8 January 2024.

Rooftop solar under base case

Stakeholder feedback suggested there is significant uptake of rooftop solar across many different types of commercial building class. That said, one stakeholder described the level of uptake on commercial buildings as 'disappointing'.

This qualitative evidence from stakeholders is consistent with the findings of recent research for the then Department of Industry, Science, Energy and Resources (DISER) (see table 4.6).[111]

4.9 Share of buildings with rooftop solar

Building type	Share of buildings with rooftop solar (Per cent)
Hotels	47%
Offices	61%
Retail	51%
Car parks	14%
Warehouses	69%
Factories	67%
Health care, schools, aged care	62%

Source: Strategy.Policy.Research. *Research report: use of renewable energy to trade-off energy efficiency requirements in Section J of the National Construction Code*, Prepared for the Department of Industry, Science, Energy and Resources, 20 January 2022, p. 4.

Voluntary uptake of rooftop solar has been incorporated into the base case. The base case is therefore represented as a weighted average of:

- buildings that comply with the minimum energy efficiency requirements set out in NCC 2022 without rooftop solar
- buildings that comply with the minimum energy efficiency requirements set out in NCC 2022 with rooftop solar (i.e. we assume that the rooftop solar is not used as an offset against other building elements).

For those buildings that voluntarily install rooftop solar, the hourly profile for electricity consumed from the grid (and electricity exported to the grid) is derived from DeltaQ's hourly energy consumption estimates for NCC 2022 combined with the hourly rooftop solar generation estimates for Stringency Level 2.

Impacts

The main benefits of the renewable energy requirements are:

- the avoided costs associated with reduced electricity consumption from the grid, including:
  avoided generation costs
  avoided network capacity costs

[111] Strategy.Policy.Research. *Research report: use of renewable energy to trade-off energy efficiency requirements in Section J of the National Construction Code*, Prepared for the Department of Industry, Science, Energy and Resources, 20 January 2022, p. 4.

avoided network usage costs

avoided retail costs, and

avoided GHG emissions.

- the increase in renewable energy exported to the grid, including:

  the value of the energy generated (as reflected in the feed-in tariff)

  avoided GHG emissions (assuming that the GHG intensity of the energy displaced by the additional energy exported to the grid reflects the average GHG intensity of the grid).

The primary cost factors are the increased capital expenditure, maintenance and disposal expenses linked to the integration of renewable energy systems. In certain instances, additional construction expenses may be necessary, such as strengthening the roof structure to accommodate the installation of PV panels.

Impacts of least cost net zero carbon ready building provisions

In addition to the more stringent minimum energy efficiency standards and mandatory rooftop solar, Stringency Level 3 aims to achieve net zero buildings in a least cost way.

As discussed above, Australia has committed to achieving net zero emissions by 2050. However, as most of the buildings constructed throughout the 2025-2034 regulatory period will still be operating in 2050, ongoing use of gas is inconsistent with the net zero target.

Buildings that typically use both electricity and gas will have a choice to either:

- Move to a fully electric building voluntarily at the time of construction (i.e. 'electrify now'), or
- Choose to use both electricity and gas (at least in the short term) apply a 'dual fuel offset' where additional solar can be added to effectively offset the use of gas in the period where there are still significant GHG emissions associated with electricity generation. This option also contains provisions to be 'ready' for future conversion to fully electric buildings in the future (i.e. reduce the cost of future electrification).

Future electrification scenario

The dual fuel offset is premised on dual fuel buildings converting to fully electric at some point in the future.

However, the timing and mechanism through which dual fuel buildings will convert to fully electric is currently unknown. Furthermore, the NCC has no control over existing buildings, so policies to encourage future conversion must be treated as external to the decision at hand (i.e. what changes should be made to the NCC).

Some states and territories are moving towards phasing out gas.

- The ACT will transition away from fossil fuel gas to renewable electricity by 2045.[112] The Issues Paper had proposed an initial regulation prohibiting all new fossil gas mains connections in residential and commercial areas across the Territory.[113]
- A Victorian parliamentary committee has recommended the Victorian government consider a ban on gas connections in new homes to help accelerate the state's transition to renewables.[114] The government has released *Victoria's Gas Substitution Roadmap* which indicates that new residential homes should be all-electric from 1 January 2024. The government is continuing to engage and collaborate with the community and industry during the gas sector's transition to net zero emissions.[115] That means that there is a possibility that some new commercial buildings built from 2025 to 2035 (the proposed period for evaluating the new buildings subject to changes made in NCC 2025) may have already been electrified, meaning there will be no need for the consideration for electrification allowances for the commercial buildings with full electrification. However, this is not clear at the moment. The recently published Roadmap update report simply reiterates 'investigating options to progressively electrify all new and existing residential and most commercial buildings'.[116]

There has been no indication from the other states and territories that they intend to move in this direction, although this could change over time as ongoing use of gas is inconsistent with net zero emissions commitments.

Stakeholders have also observed that electrification initiatives are possibly underway at the council level in other states. For example, CitySwitch, in partnership with cities of Sydney, Melbourne, Adelaide, Ballarat, Yarra, North Sydney Council, Waverley Council and NABERS, is helping office-based businesses reduce their

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[112] See ACT Government, 'Powering Canberra: Our Pathway to Electrification', in *ACT Government - Canberra is Electrifying*, 2023, https://energy.act.gov.au/, accessed 2 November 2023; and M Mannheim, 'No new gas connections for Canberra homes and businesses from next year', in *ABC News*, 4 August 2022, https://www.abc.net.au/news/2022-08-04/act-no-new-gas-connections-from-2023-new-homes/101299552, accessed 3 November 2023.

[113] ACT Government, *Community and Stakeholder Engagement Report - Pathway to Electrification: Regulation to prevent new fossil fuel gas network connections*, ACT Government, June 2023, https://yoursayconversations.act.gov.au/pathway-to-electrification/help-inform-regulation-prevent-new-gas-connections, accessed 3 November 2023.

[114] A Ore, 'Ban on new gas connections will help transition Victoria away from fossil fuels, inquiry finds', in *The Guardian*, 26 May 2022, section Environment, https://www.theguardian.com/environment/2022/may/26/ban-on-new-gas-connections-will-help-transition-victoria-away-from-fossil-fuels-inquiry-finds, accessed 3 November 2023.

[115] Planning Victoria, 'Victoria's Gas Substitution Roadmap', in *the Victorian Government - Renewable energy*, 2023, https://www.planning.vic.gov.au/guides-and-resources/strategies-and-initiatives/victorias-gas-substitution-roadmap, accessed 2 November 2023.

[116] Victoria State Government 2024, *Victoria's Gas Substitution Roadmap Update: Victoria's Electrification Pathway*, p. 3, https://www.energy.vic.gov.au/__data/assets/pdf_file/0027/691119/Victorias-Gas-Substitution-Roadmap-Update.pdf, accessed 7 February 2024

carbon emissions including switching to 100 per cent renewables.[117] Further data is required to construct a base case of electrification for these regions. However, it has been suggested that any electrification efforts are likely to be on a small scale.

Although CBA should take into account any foreseeable future policy changes, most states have not given any indication that they are moving in this direction (except ACT and Victoria), even though ongoing gas use is inconsistent with net zero targets. Our central case scenario therefore assumes ongoing use of gas in dual fuel buildings over the life of the building.

That said, it is also plausible that dual fuel buildings will be required to convert to fully electric in the future consistent with the overarching premise of Stringency Level 3 requirements. To obtain a more complete understanding of the potential impacts of Stringency Level 3, we also consider a scenario where dual fuel buildings are required to electrify in the future.

Under this scenario, the timing of future conversion is unclear; we assume that conversion occurs when the gas boiler needs replacing. For consistency with the assumptions in relation to the life of equipment, we assume this would occur after 20 years.

Impacts

The impacts of the net zero provisions will depend on factors such as:

- the choice of compliance approach (i.e. the dual fuel offset or the electrify now option);
- the future electrification scenario (see discussion above).

The impacts could include the following:

- the cost of complying with the net zero provisions, which could include:
  - for the dual fuel offset options, the costs include:
    - the cost of the additional solar (mostly ground-mounted solar);
    - the cost of the 'electrification readiness' measures;
    - any loss of aesthetic/amenity value from ground-mounted solar panels.
  - for the 'electrify now' option, the compliance costs would include the additional cost of fully-electric HVAC equipment.
- Under a future electrification scenario:
  - The cost of converting to fully electric would be lower (relative to the base case) under the dual fuel offset option;
  - Under the 'electrify now' option, there would be no need for future conversion.
- The energy-related impacts would be as follows:
  - Under the 'dual fuel offset' option:

117 https://cityswitch.net.au/

    - there would be more electricity generated on-site from the additional PV resulting in less energy consumer from the grid and more energy exported to the grid;
    - the benefits would continue over the life of the building regardless of the future electrification scenario.
- Under the 'electrify now' option, there would be:
    - no gas consumption;
    - this would be offset by higher electricity consumption.

It is also important that the future electrification assumption is applied consistently across the various stringencies (including the base case) so that the options are comparable under each scenario (see table 4.10 for a summary of the benefits and costs for each stringency level — including the base case — under each of the future electrification scenarios).

4.10 Electrification scenarios — benefits and costs

Stringency	No future electrification scenario	Future electrification scenario
NCC 2022 (base case)	▪ Energy consumption based on NCC 2022. ▪ Costs based on dual fuel installation with like-for-like replacement over life of the building.	▪ Energy consumption based on: – NCC 2022 for first 20 years. – A fully-electric building with NCC 2022 levels of energy efficiency thereafter. ▪ Future conversion costs (unplanned).
NCC 2025 Stringency Level 1	▪ Energy consumption based on NCC 2025 stringency with dual fuel. ▪ Costs based on dual fuel installation with like-for-like replacement over life of the building.	▪ Energy consumption based on: – NCC 20222 with dual fuel for first 20 years. – A fully-electric building with NCC 2025 levels of energy efficiency thereafter. ▪ Costs include: – Initial installation of dual fuel equipment. – Future conversion costs (unplanned) after 20 years. – Replacement of all-electric equipment over remaining life of building.
NCC 2025: Stringency Level 2	▪ Energy consumption/export based on NCC 2025 stringency (dual fuel) with PV. ▪ Costs based on dual fuel installation with like-for-like replacement over life of the building.	▪ Energy consumption based on: – NCC 2022 with dual fuel with PV for first 20 years. – a fully-electric building with NCC 2022 levels of energy efficiency and PV thereafter. ▪ Costs include: – Initial installation of dual fuel equipment. – Future conversion costs (unplanned) after 20 years.

Stringency	No future electrification scenario	Future electrification scenario
		– Replacement of all-electric equipment over remaining life of building.
NCC 2025: Stringency Level 3 — dual fuel choice	▪ Energy consumption/export based on NCC 2025 stringency (dual fuel) with additional PV. ▪ Costs include: – dual fuel installation with like-for-like replacement over life of the building. – additional PV (dual fuel offset). – cost of electrification readiness.	▪ Energy consumption based on: – NCC 2022 with dual fuel with additional PV for first 20 years. – a fully-electric building with NCC 2022 levels of energy efficiency and additional PV thereafter. ▪ Costs include: – Initial installation of dual fuel equipment. – Future conversion costs (planned) after 20 years. – Replacement of all-electric equipment over remaining life of building.
NCC 2025: Stringency Level 3 — electrification choice	▪ Energy consumption/export based on all-electric building with PV. ▪ Costs include additional cost of all-electric equipment (including replacement costs over life of building).	▪ Energy consumption/export based on all-electric building with PV (no conversion required). ▪ Costs include additional cost of all-electric equipment (including replacement costs over life of building).

Source: CIE.

It is clear from table 4.7 that the impacts will be significantly different depending on the choice of the dual fuel offset or the electrify now response. This is likely to depend on factors such as:

- the relative cost of each approach;
- the feasibility of installing ground-mounted solar (this may not be possible in CBD-type areas where space and shading are likely to limit).

In the modelling we assume the choice of approach is split 50:50 across the two options.

Key differences from DeltaQ's building-level CBA results

Although DeltaQ's building-level modelling is a key input into the building-level CBA results that feed into the aggregate estimates and are based on the same parameters and used many of the same inputs, there are some key differences as follows:

- Our estimates incorporate voluntary uptake of rooftop solar into the base case:
  - Our base case is therefore a weighted average of:
    - buildings built to comply with NCC 2022 (with no rooftop solar); and
    - buildings built to comply with NCC 2022 with rooftop solar added.
  - By contrast, DeltaQ's base case assumes no rooftop solar (as rooftop solar is not mandatory under NCC 2022).
- Our estimates of the avoided electricity-related costs incorporate:

  - pricing variations across states and territories (DeltaQ's results are based on a weighted average price at the national level).
  - time-based variation in prices by hourly interval across the year (the details of time of use estimation and information sources are provided in appendix B).
- Our building-level estimates reflect expected changes in the expected costs and benefits depending on the year of construction.
  - As the CBA covers the period from 2025 to 2034, the costs and benefits vary over time, reflecting expected changes in:
    - energy prices
    - the GHG emissions-intensity of electricity generation
    - the social cost of carbon
  - By contrast, DeltaQ's building-level CBA results reflect buildings constructed in 2025.

Impacts of mandating electric vehicle charging facilities

The proposed changes to the NCC in relation to electric vehicles are expected to be related to the provision of charging facilities at some commercial buildings, including:

- hotels
- offices
- factories
- warehouses
- hospitals
- aged care facilities.

Uptake of EVs is widely seen as an essential component of reducing transport GHG emissions to reach aggregate net zero emissions by 2050. Electric vehicle sales in Australia are lower than in many other comparable countries, but are increasing rapidly (in percentage terms). EVs are estimated to have made up around 8 per cent of new car sales in Australia in 2023 — double the share observed in 2022.[118]

All Australian states and territories have agreed to the National Electric Vehicle Strategy framework and key areas for national collaboration to ensure a national approach to EVs. This builds on existing Commonwealth and state governments' policy measures in place to encourage the uptake of EVs.

The availability of charging facilities has been identified as a key barrier to widespread uptake of electric vehicles in Australia (along with high purchase price, limited supply and beliefs regarding vehicle range and charging time). This interdependence between EV adoption and charging station investment is referred to

118 DCCEEW 2024, 'Reducing transport emissions', Australian Government, https://www.dcceew.gov.au/energy/transport, accessed 8 February 2024.

as an 'indirect network effect' (or the chicken and the egg problem): the benefit of adoption/investment on one side of the market increases with the network size of the other side of the market.[119]

- Even when EV owners can charge their vehicles overnight at home, some consumers still worry about running out of electricity before reaching their destination. This 'range anxiety' limits adoption of electric vehicles, especially when public charging stations are scarce.
- At the same time, private investors have less incentive to build charging stations if the size of the EV fleet and the market potential are small.

Governments are co-investing with industry to roll out networks of public highway and metropolitan fast charging stations. The availability of destination charging facilities where the car is parked for a period of time (such as office buildings or shopping centres) is also an important factor to encourage EV uptake.

The benefits of mandating EV charging facilities could be measured through:

- additional consumer surplus to
  - consumers using EVs in the base case, and
  - consumers induced to use EVs (using the rule of one half)
- GHG emissions avoided due to induced substitution from internal combustion vehicles to EVs;
- Air pollution avoided due to induced substitution from internal combustion vehicles to EVs.

Benefits to building owners in terms of increased demand for their buildings are reflected in the consumer surplus measures listed above.

Previous CIE work has quantified consumers' willingness to pay for various characteristics of electric vehicles (such as price, range and operating costs) and the supporting infrastructure (such as availability of charging stations along highways and at destinations, such as shopping centres) through a stated preference survey.[120] This work provides insight into the extent to which availability of charging facilities at commercial building destinations (such as offices and shopping centres) could benefit EV users and affect uptake of EVs, relative to the base case (i.e. with no requirement for charging facilities at commercial buildings). While a more recent study would be ideal, the range of charging availability levels used in the survey are suitable for the forecasts developed in this CRIS and we are not aware of a more recent Australian study quantifying the charging-infrastructure-availability elasticity of demand for EVs. We are also unaware of any evidence indicating this elasticity is likely to have changed over the past five years.

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119 Li, S., L. Tong, J. Xing and Y. Zhou 2017, 'The Market for Electric Vehicles: Indirect Network Effects and Policy Design', *Journal of the Association of Environmental and Resource Economics*, January 2017, p. 88.

120 CIE 2019, *Demand for electric vehicles: A discrete choice survey*, report prepared for Australian Automobile Association, The Centre for International Economics, https://www.thecie.com.au/publications-archive/demand-for-electric-vehicles

In addition to costs associated with installation of the facilities, stakeholders have indicated that higher load/capacity requirements for charging stations would lead to increased electricity demand. The industry is actively developing a load management system, which is anticipated to mitigate the impact of this cost increase.

Furthermore, charging facilities may pose a fire risk, particularly during the charging process. While data on EV fires are relatively scarce due to the early stage of uptake, it is believed that EV fires are rare and less frequent than petrol and diesel vehicles.[121] Nevertheless, the current state of battery technology renders them difficult to extinguish once ignited, meaning the expected damage may be high. Consequently, additional expenses may be necessary to mitigate this risk, such as implementing structural reinforcements and providing extra buffer space to allow for physical isolation.

The ABCB engaged EV FireSafe to investigate EV risks and published an advisory note to support the safer installation and use of EV chargers. As a result, this CRIS will not separately quantify the costs of mitigating fire risk of EV charging.

EV take up in the base case

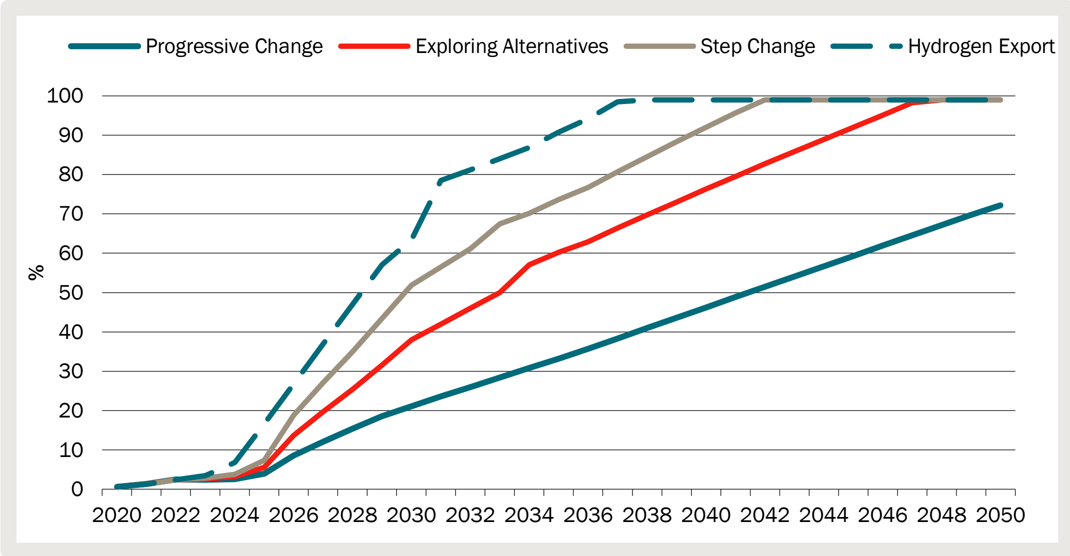
The Commonwealth Scientific and Industrial Research Organisation (CSIRO) provided AEMO with electric vehicle sales and fleet share projections up to 2050, encompassing four scenarios.[122] Among these scenarios, the Progressive Change scenario represents the slowest uptake, while the Hydrogen Export scenario exhibits the swiftest uptake (chart 4.11 and 4.12).

For our analysis, we choose the Step Change scenario as the central case. According to this scenario, EV sales are anticipated to account for 99 per cent of all new vehicle sales by 2042 (chart 4.11), with EVs making up 99 per cent of entire fleet by 2050 (chart 4.12).

121 H Dia, 'Electric vehicle fires are very rare. The risk for petrol and diesel vehicles is at least 20 times higher', The Conversation, 2023, https://theconversation.com/electric-vehicle-fires-are-very-rare-the-risk-for-petrol-and-diesel-vehicles-is-at-least-20-times-higher-213468, accessed 3 November 2023.

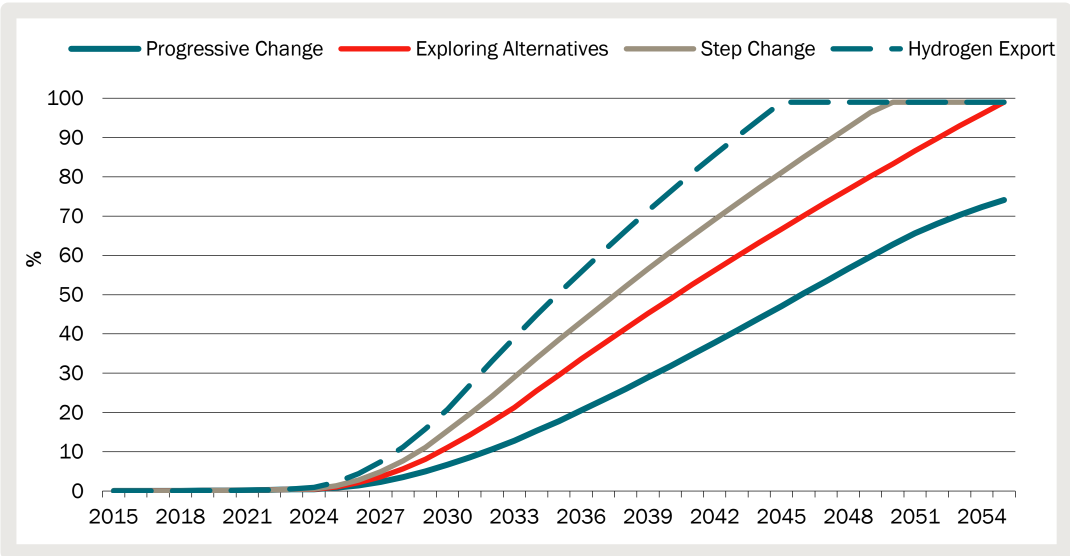
122 P Graham 2022, *Electric vehicle projections 2022 - Commissioned for AEMO's draft 2023 Input, Assumptions and Scenarios Report*, CSIRO, 2022, https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/csiro-2022-electric-vehicles-projections-report.pdf?la=en, last accessed 6 February 2024

4.11 Projected EV sales share



Data source: Graham (2022), Table B.1, 9.59.

4.12 Projected EV fleet share



Data source: Graham (2022), Table B.2, p.60

More details of EV assumptions and methodology are provided in the appendix D.

5 *Building-level impacts*

The evaluation of building-level impacts is derived from a comprehensive analysis that incorporates the findings of energy modelling, alongside previously provided information on energy pricing, emission valuation and baseline uptake of solar PV systems. More specifically, the building-level impacts encompass:

- the modelled changes in energy consumption and emissions; and
- CBA outcomes at the building level, quantifying energy-related cost savings and changes in construction cost per square metre of floor space.

These building-level impacts serves as the foundation for the aggregate impacts, which will be presented in the next chapter. Moreover, the outcomes at the building level plays a crucial role in elucidating the aggregate results.

Building-level energy modelling

As mentioned in the previous chapter, the impact analysis including CBA is based on building level impacts modelled by DeltaQ.

DeltaQ estimates the changes in:

- energy consumption
- GHG emissions, and
- capital-related costs (including both building envelope, HVAC equipment and solar PV systems)

DeltaQ has modelled these key variables:

- for each the three proposed stringency levels
- for 10 building archetypes:
  - Hotels (C3HL)
  - Motels (C3HS)
  - Large office building (C5OL)
  - Medium office building (C5OM)
  - Small office building (C5OS)
  - Big box retail (C6RL)
  - Strip shops (C6RS)
  - Large hospital ward (C9A)
  - School classroom block (C9B)

 – Small hospital (C9AS) which can be applied to Aged care facility (C9C)[123]
- in 8 climate zones (see appendix E for details).

Based on DeltaQ modelling results, changes in energy-related costs are estimated using state specific time of use price information.

Stringency Level 1: Cost-effective energy efficiency without mandated on-site PV

Modelled changes in energy consumption and emissions

Table 5.1 summarises the percentage change in electricity and gas consumption and GHG emissions under Stringency Level 1 for each archetype and climate zone compared to the reference case (NCC 2022), modelled by DeltaQ.

Note that for each building archetype and climate zone, DeltaQ's modelling compares a building built to meet the proposed requirements under NCC 2025 with a NCC 2022-compliant building. However, as discussed above, the base case used for the CRIS modelling incorporates voluntary uptake of rooftop solar.

5.1 Modelled energy consumption and emissions change – Stringency Level 1

Fuel or emissions	CZ1 (%)	CZ2 (%)	CZ3 (%)	CZ4 (%)	CZ5 (%)	CZ6 (%)	CZ7 (%)	CZ8 (%)
Hotels (C3HL)								
Electricity	-14	-20	-17	-13	-19	-14	-15	-7
Gas	n/a	44	12	8	33	23	12	11
GHG	-14	-19	-16	-9	-16	-8	-8	0
Motels (C3HS)								
Electricity	-25	-18	-29	-16	-23	-14	-16	-11
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-25	-18	-29	-16	-23	-14	-16	-11
Large office building (C5OL)								
Electricity	-17	-23	-23	-19	-21	-19	-19	-18
Gas	n/a	-4	-16	-2	4	4	-3	9
GHG	-17	-22	-23	-18	-21	-18	-17	-10

123 Small hospital (C9AS) was modelled by DeltaQ because aged care building (C9C) has very short HVAC running hours according to NCC 2022 schedules and thus was not an appropriate test bed. The results are applied to aged care facilities in the CBA.

Fuel or emissions	CZ1 (%)	CZ2 (%)	CZ3 (%)	CZ4 (%)	CZ5 (%)	CZ6 (%)	CZ7 (%)	CZ8 (%)
Medium office building (C5OM)								
Electricity	-29	-29	-37	-31	-31	-28	-24	-18
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-29	-29	-37	-31	-31	-28	-24	-18
Small office building (C5OS)								
Electricity	-21	-11	-25	-20	-23	-22	-18	-22
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-21	-11	-25	-20	-23	-22	-18	-22
Big box retail (C6RL)								
Electricity	-24	-28	-32	-20	-25	-13	-21	-16
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-24	-28	-32	-20	-25	-13	-21	-16
Strip shops (C6RS)								
Electricity	-32	-32	-38	-30	-31	-24	-22	-17
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-32	-32	-38	-30	-31	-24	-22	-17
Large hospital ward (C9A)								
Electricity	-16	-7	-14	-5	-10	-3	-4	-2
Gas	n/a	-2	-37	14	43	25	4	10
GHG	-16	-7	-15	-3	-10	-2	-3	1
School classroom block (C9B)								
Electricity	-18	-23	-22	-19	-22	-20	-18	-14
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-18	-23	-22	-19	-22	-20	-18	-14
Small hospital (C9AS) [a]								
Electricity	-16	-27	-18	-18	-23	-27	-16	-17
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-16	-27	-18	-18	-23	-27	-16	-17

[a] Aged care facility (C9C) is modelled by DeltaQ as a small hospital (C9AS) because aged care building had very short HVAC running hours according to NCC 2022 schedules so wasn't an appropriate test bed.

Note: n/a. – not available, indicates no gas consumption in the baseline

Source: DeltaQ building level modelling

It should be noted that only three archetypes (C3HL, C5OL and C9A) are modelled as dual fuel buildings in the base case. The other seven modelled archetypes do not use gas and therefore there are no changes in gas consumption (entered as 'n/a' in the table). Gas is generally used for heating, and thus not relevant for Climate Zone 1.

As can be seen from the table, the proposed changes in energy efficiency provisions under Stringency Level 1 are estimated to have significant reductions in energy consumption and associated GHG emissions, compared to the reference case (NCC 2022). In most cases, the reduction is estimated to be between 10 and 20 per cent, highest reduction is generally seen in C6RS while lowest reduction in C9A.

As discussed above, the avoided electricity-related costs also depend on the time of day those energy savings are expected to occur. The time of day that energy savings are expected to occur varies across different building archetypes, climate zones and seasons.

Charts summarising electricity savings in each hourly interval across an average week in each of the four seasons (for selected building archetype and selected climate zone combination) are presented in appendix F.

In some cases, gas consumption is modelled to increase. This is because the solar admittance measure reduces cooling needs, which achieves overall energy and emissions savings, but increases heating needs in winter. Therefore, some dual-fuel models showed an increase in gas use. This leads to an increase in gas costs in the CBA results (as this is a cost it is shown as a negative number in the CBA below).

Building-level CBA

The building-level CBA for Stringency Level 1 for the large office building archetype (C5OL) for the climate zone that contains the capital city in each state is shown in table 5.2.[124] These estimates are presented in present value terms over the (assumed) 50-year life of the building using a discount rate of 5 per cent.

5.2 Building-level CBA for Stringency Level 1 — C5OL

Impact	NSW (CZ5) $ per m²	VIC (CZ6) $ per m²	QLD (CZ2) $ per m²	WA (CZ5) $ per m²	SA (CZ5) $ per m²	TAS (CZ7) $ per m²	ACT (CZ7) $ per m²	NT (CZ1) $ per m²
Change in electricity network capacity costs	6.39	2.18	8.52	1.39	3.36	6.44	3.11	9.84

124 Building-level CBA results have been estimated for each relevant Climate Zones for each state and territory, but are not reported.

Impact	NSW (CZ5) $ per m²	VIC (CZ6) $ per m²	QLD (CZ2) $ per m²	WA (CZ5) $ per m²	SA (CZ5) $ per m²	TAS (CZ7) $ per m²	ACT (CZ7) $ per m²	NT (CZ1) $ per m²
Change in electricity generation costs	12.52	8.31	13.81	6.87	9.89	8.20	8.87	21.92
Change in electricity network usage costs	6.12	6.68	8.68	15.49	14.31	3.43	5.74	7.26
Change in electricity retail costs	3.75	2.58	4.65	3.56	4.13	2.71	2.66	5.85
Value of energy exported to the grid	0.04	0.00	0.02	0.03	0.06	0.02	0.01	0.10
Change in gas costs	-0.07	-0.23	0.02	-0.07	-0.08	0.98	0.69	0.00
Change in GHG emission costs - electricity	6.72	12.57	19.60	12.13	4.57	1.08	4.41	21.90
Change in GHG emission costs – exported electricity	0.04	0.05	0.06	0.08	0.03	0.00	0.01	0.12
Change in GHG emission costs - gas	-0.15	-0.39	0.04	-0.14	-0.13	1.23	1.43	0.00
Change in capital-related costs	-18.45	-11.19	-33.25	-18.45	-18.45	-14.01	-14.01	-28.70
Total	**16.92**	**20.56**	**22.16**	**20.89**	**17.70**	**10.08**	**12.90**	**38.30**

Note: Estimates presented in present value terms based on: buildings constructed in 2025 assuming a 50-year life, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

The net benefits for all archetypes for each state (capital city climate zone) are summarised in table 5.3. Detailed CBA results for each archetype are provided in appendix G. The proposed changes are estimated to deliver net benefits across all building archetypes.

5.3 Building-level net benefits for Stringency Level 1 by archetype

Building	NSW (CZ5) $ per m²	VIC (CZ6) $ per m²	QLD (CZ2) $ per m²	WA (CZ5) $ per m²	SA (CZ5) $ per m²	TAS (CZ7) $ per m²	ACT (CZ7) $ per m²	NT (CZ1) $ per m²
C3HL	60.43	37.98	99.81	63.52	63.66	36.61	39.81	124.34
C3HS	114.25	83.01	269.96	124.93	121.01	84.26	88.69	285.56
C5OL	16.92	20.56	22.16	20.89	17.70	10.08	12.90	38.30
C5OM	75.68	68.43	101.36	80.77	74.17	58.16	58.11	160.79
C5OS	65.08	84.59	56.63	64.69	63.17	70.36	58.61	151.26
C6RL	187.21	76.45	335.83	206.24	193.82	166.42	169.34	407.24
C6RS	274.41	247.53	430.22	299.69	273.70	172.99	178.83	680.97
C9A	36.33	21.14	34.80	39.42	37.65	19.43	19.45	80.92
C9B	74.08	68.69	130.15	72.49	66.99	74.22	66.10	151.63
C9C [a]	57.08	165.80	127.66	64.60	60.11	52.76	54.60	112.44

[a] Aged care facility (C9C) is modelled by DeltaQ as a small hospital (C9AS) because aged care building had very short HVAC running hours according to NCC 2022 schedules so wasn't an appropriate test bed.

Note: Estimates presented in present value terms based on: buildings constructed in 2025 assuming a 50-year life, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Change in energy-related costs

As discussed above, the base case used for the CRIS modelling includes a mix of buildings that voluntarily install rooftop solar and those that do not. Compared with the base case, the increase in the minimum energy efficiency requirements would:

- reduces the consumption of electricity from the grid in some periods
- change the amount of gas consumed — this varies across building archetypes and climate zones:

  for some building archetypes and climate zones gas consumption increases

  for other building archetypes and climate zones, gas consumption decreases.
- increase the amount of electricity exported to the grid (due to reduced consumption on site) in some periods for those buildings that voluntarily install rooftop solar.

The value of the avoided costs depends on a range of factors, including: the marginal cost of generation in the relevant location during the relevant periods, the timing of the electricity savings relative to typical network peaks, network capacity and the GHG intensity of electricity in the relevant location.

Although these factors vary across regions, we estimate the change in energy-related costs at the state level. These state-level estimates capture state-based variation in:

- the marginal cost of generation across states (as reflected in differences in the wholesale price);
- typical consumption peaks across states (as reflected in differences in different charging arrangements for peak periods);
- the long-run marginal cost of network supply (as reflected in differences in charging arrangements for peak periods), which in principle should reflect differences in network capacity;
- the emissions intensity of electricity.

The estimated change in energy-related costs per square metre of floor space for each building archetypes that have been modelled (medium office building, large office building, large hospital ward and aged care facility) in each state/territory and in each climate zone are presented below. These estimates are presented in present value terms:

- assuming the building has a life of 50 years;
- using a discount rate of 5 per cent;
- based on a building constructed in 2025 — note that the energy-related benefits vary by the year of construction reflecting:
  – projected changes in the price of energy over time;
  – changes in the social cost of carbon over time;
  – changes in the emissions intensity of electricity over time.

Change in capital-related costs

Changes in capital-related costs across the ten building archetypes that have been modelled across each climate zone are summarised in table 5.4.

These estimates are presented in present value terms over the (assumed) 50-year life of the building using a discount rate of 5 per cent. Replaceable equipment is assumed to be replaced after 20 years.

5.4 Changes in capital-related costs over building life – Stringency Level 1

Building	1	2	3	4	5	6	7	8
	$/m²	$/m²	$/m²	$/m²	$/m²	$/m²	$/m²	$/m²
C3HL	46.77	39.00	40.16	17.96	29.37	21.92	28.21	60.46
C3HS	82.17	39.76	31.03	33.43	51.63	33.08	27.47	39.15
C5OL	-28.70	-33.25	-32.11	-9.75	-18.45	-11.19	-14.01	-8.54
C5OM	-3.67	-0.36	22.44	10.47	6.79	-5.56	3.11	-5.92
C5OS	10.47	17.52	18.82	18.14	11.32	22.91	1.59	1.60
C6RL	-54.25	7.96	-1.10	-71.41	-3.08	-52.77	-46.60	-135.51
C6RS	18.90	4.16	47.56	20.51	9.38	-16.25	-21.21	-34.74
C9A	-2.53	12.65	0.13	12.38	16.05	15.77	15.55	23.63
C9B	13.10	31.83	16.36	13.13	14.74	8.09	6.68	0.67
C9C [a]	12.69	26.64	35.59	31.62	10.58	77.30	7.41	-31.28

[a] Aged care facility (C9C) is modelled by DeltaQ as a small hospital (C9AS) because aged care building had very short HVAC running hours according to NCC 2022 schedules so wasn't an appropriate test bed.

Note: A positive number indicates that costs are estimated to be lower under proposed changes (i.e. a benefit). A negative number indicates that capital-related costs are estimated to be higher under the proposed changes (i.e. a cost).

Source: DeltaQ modelling, CIE.

A positive number in the table indicates that costs are estimated to be lower under proposed changes compared to the reference case. As shown in the table, there exist capital cost reductions associated with higher energy efficiency stringency requirements for many cases. These peculiar results are due to the following factors:

- to a large extent the capital cost savings are due to smaller HVAC equipment sizes which are in turn a result of better (more energy efficient) building envelopes
- improvements in the Code, for example:
  - clarifying the definition of building envelope to avoid having to install insulation in internal walls
  - relaxation of external wall-glazing U-Value requirements in some building classifications and climate zones.
- some preference changes in glazing selections (i.e. selecting darker windows in the policy case than the reference case).

The magnitude of the impacts of these factors may vary across different cost items for different archetypes and climate zones, leading to different total impacts.

Stringency Level 2: Cost-effective energy efficiency standards with mandated on-site PV

Stringency Level 2 involves the same measures to increase the stringency of the minimum energy efficiency standards as for Stringency Level 1, plus a mandatory requirement for rooftop solar.

Modelled changes in energy consumption and emissions

The modelled energy savings under Stringency Level 2 are summarised in table 5.5. Compared with Stringency Level 1, less electricity from the grid is consumed and during some periods, some of the excess electricity generated is exported to the grid.

5.5 Modelled energy consumption and emissions change – Stringency Level 2

Fuel or emissions	CZ1 (%)	CZ2 (%)	CZ3 (%)	CZ4 (%)	CZ5 (%)	CZ6 (%)	CZ7 (%)	CZ8 (%)
Hotels (C3HL)								
Electricity	-18	-27	-23	-21	-27	-23	-23	-16
Gas	n/a	44	12	8	33	23	12	11
GHG	-18	-26	-21	-16	-24	-16	-14	-4
Motels (C3HS)								
Electricity	-44	-46	-54	-39	-49	-43	-38	-29
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-260	-631	-535	-553	-619	-667	-590	-395
Large office building (C5OL)								
Electricity	-29	-38	-41	-43	-40	-40	-41	-44
Gas	n/a	-4	-16	-2	4	4	-3	9
GHG	-32	-40	-44	-47	-45	-40	-36	-33
Medium office building (C5OM)								
Electricity	-72	-95	-94	-100	-100	-105	-102	-79
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-233	-382	-339	-409	-385	-452	-475	-369
Small office building (C5OS)								
Electricity	-65	-85	-87	-90	-100	-99	-89	-72

Fuel or emissions	CZ1 (%)	CZ2 (%)	CZ3 (%)	CZ4 (%)	CZ5 (%)	CZ6 (%)	CZ7 (%)	CZ8 (%)
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-236	-407	-379	-432	-452	-476	-467	-395
Big box retail (C6RL)								
Electricity	-49	-66	-65	-58	-63	-52	-57	-44
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-49	-76	-67	-72	-78	-85	-81	-61
Strip shops (C6RS)								
Electricity	-65	-72	-73	-70	-72	-66	-65	-48
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-66	-91	-84	-110	-104	-130	-127	-77
Large hospital ward (C9A)								
Electricity	-65	-72	-73	-70	-72	-66	-65	-48
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-66	-91	-84	-110	-104	-130	-127	-77
School classroom block (C9B)								
Electricity	-51	-77	-71	-73	-78	-79	-72	-48
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-240	-432	-428	-540	-538	-693	-619	-417
Small hospital (C9AS) [b]								
Electricity	-62	-76	-66	-64	-77	-77	-60	-46
Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GHG	-564	-572	-532	-626	-631	-647	-559	-329

[a] Change in GHG emissions includes emissions reductions of electricity exported from PV systems to replace electricity from the grid.

[b] Aged care facility (C9C) is modelled by DeltaQ as a small hospital (C9AS) because aged care building had very short HVAC running hours according to NCC 2022 schedules so wasn't an appropriate test bed.

Note: N/R. – not relevant, indicates no gas consumption in the baseline

Source: DeltaQ building level modelling

Including electricity generated from PV systems exported to the grid to replace grid-wide generation and thus avoiding grid average emissions of electricity generation, the GHG emissions reductions are significantly higher under Stringency Level 2 than under Stringency Level 1.

In many cases, for example motels (C3HS), medium and small office buildings (C5OM and C5OS), classroom blocks (C9B) and aged care facilities (C9C), GHG emissions reduce by more than 100 per cent under Stringency Level 2 compared to the NCC 2022 base case. This is due to exported electricity from solar PV systems which avoids emissions in the grid before it decarbonises.

Gas consumptions in some cases are modelled to increase under Stringency Level 2, for the same reason with Stringency Level 1 mentioned above.

As with Stringency Level 1, charts showing modelled electricity savings by time of day under Stringency Level 2 are presented in appendix F.

Building-level CBA

The building-level CBA for Stringency Level 2 for the large office building archetypes (C5OL) for the climate zone that contains the capital city in each state is shown in table 5.6.[125] These estimates are presented in present value terms over the (assumed) 50-year life of the building using a discount rate of 5 per cent.

5.6 Building-level CBA for Stringency Level 2 — C5OL

Impact	NSW (CZ5) $ per m²	VIC (CZ6) $ per m²	QLD (CZ2) $ per m²	WA (CZ5) $ per m²	SA (CZ5) $ per m²	TAS (CZ7) $ per m²	ACT (CZ7) $ per m²	NT (CZ1) $ per m²
Change in network electricity capacity costs	7.96	3.17	10.07	1.71	4.27	9.09	4.51	13.53
Change in electricity generation costs	16.36	11.35	16.52	9.01	12.27	11.48	12.15	27.98
Change in electricity network usage costs	8.32	10.36	10.93	21.12	19.55	5.18	8.74	9.21
Change in electricity retail costs	4.90	3.73	5.63	4.78	5.41	3.86	3.81	7.61
Value of energy exported to the grid	0.09	0.01	0.04	0.07	0.14	0.04	0.02	0.20
Change in gas costs	-0.07	-0.23	0.02	-0.07	-0.08	0.98	0.69	0.00
Change in GHG emission costs - electricity	9.08	17.95	24.89	16.40	6.18	1.56	6.35	27.79
Change in GHG emission costs – exported electricity	0.10	0.09	0.11	0.17	0.06	0.01	0.02	0.23
Change in GHG emission costs - gas	-0.15	-0.39	0.04	-0.14	-0.13	1.23	1.43	0.00
Change in capital-related costs	-23.69	-15.49	-37.33	-23.69	-23.69	-18.06	-18.06	-33.64
Total	**22.91**	**30.56**	**30.91**	**29.36**	**23.99**	**15.36**	**19.67**	**52.91**

Note: Estimates presented in present value terms based on: buildings constructed in 2025 assuming a 50-year life, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

The net benefits for all archetypes for each state and territory (capital city climate zone) are summarised in table 5.7. Detailed CBA results for each archetype are provided in appendix G.

125 Building-level CBA results have been estimated for each relevant Climate Zones for each state and territory, but are not reported.

Key findings from the building-level analysis are as follows:

- The proposed changes are estimated to deliver net benefits across all building archetypes.
- The net benefits for each archetype are higher than for Stringency Level 1.

5.7 Building-level net benefits for Stringency Level 2 by archetype

Building	NSW (CZ5)	VIC (CZ6)	QLD (CZ2)	WA (CZ5)	SA (CZ5)	TAS (CZ7)	ACT (CZ7)	NT (CZ1)
	$ per m²	$ per m²	$ per m²	$ per m²	$ per m²	$ per m²	$ per m²	$ per m²
C3HL	63.80	45.34	105.76	69.00	67.56	39.04	43.81	133.46
C3HS	131.23	139.43	333.27	158.25	141.94	98.44	114.04	376.57
C5OL	22.91	30.56	30.91	29.36	23.99	15.36	19.67	52.91
C5OM	104.36	132.92	159.77	123.61	104.93	87.08	98.83	239.08
C5OS	93.97	154.96	119.47	109.57	94.84	100.55	101.93	231.55
C6RL	252.87	220.36	461.66	303.92	263.10	220.43	258.15	579.66
C6RS	354.68	415.49	582.86	415.13	355.98	240.64	283.54	926.73
C9A	42.17	32.21	44.26	48.68	44.11	23.40	27.04	92.82
C9B	105.11	129.29	194.77	113.77	95.70	102.76	106.64	242.70
C9C [a]	77.12	222.73	183.27	101.33	84.67	69.62	85.53	232.35

[a] Aged care facility (C9C) is modelled by DeltaQ as a small hospital (C9AS) because aged care building had very short HVAC running hours according to NCC 2022 schedules so wasn't an appropriate test bed.

Note: Estimates presented in present value terms based on: buildings constructed in 2025 assuming a 50-year life, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Change in energy-related costs

The impacts of Stringency Level 2 on energy-related costs are as follows.

- For buildings that would voluntarily install rooftop solar in the base case scenario, the impacts are the same as for Stringency Level 1; an increase in the minimum energy efficiency requirements leading to:
  - a reduction in electricity consumed from the grid
  - an increase in electricity exported to the grid
  - a change in gas consumption (which varies across building archetypes and climate zones).
- For buildings that would not voluntarily install rooftop solar in the base case scenario, the impacts include:
  - a reduction in electricity consumption from the grid (greater than Stringency Level 1)
  - an increase in electricity exported to the grid (greater than Stringency Level 1)
  - a change in gas consumption, which varies across building archetypes and climate zones (the impact on gas consumption would be the same as Stringency Level 1 as the installation of rooftop solar has not impact on gas consumption).

These changes in energy-related costs are measured as previously described.

Change in capital-related costs

The main difference to Stringency Level 1 is PV system-related costs, including the cost of the system (including replacement of the system after 20 years) and the cost of annual maintenance. As a result, capital-related costs are significantly higher under Stringency Level 2, compared with Stringency Level 1.

Stringency Level 3: Least cost net zero carbon ready buildings

Modelled changes in energy consumption and emissions

DeltaQ has modelled Stringency Level 3 with several scenarios to consider the following variations:

- Baseline – dual-fuel forever versus assumed electrification in Year 15
- PV system – rooftop PV only versus rooftop and ground-based PV systems (expanded PV)
- Electrification planning and date in the test case – unplanned electrification in Year 15 (that does not have any ‘electrification readiness’ preparation at the beginning), planned electrification in Year 15 (that has ‘electrification readiness’ preparation at the beginning) and immediate electrification from beginning.

The ground-based PV systems are used under the expanded PV scenario for Stringency Level 3 because, for most archetypes, all the available roof space is already used to accommodate the PV required for Stringency Level 2, with no space left for the additional PV that is used in dual-fuel buildings to offset the incremental emissions associated with the gas-based appliances.

As mentioned previously, only three archetypes (C3HL, C5OL and C9A) have gas consumption in the base case and are thus relevant for the modelling of electrification (i.e. all other archetypes are already fully electrified). For more detailed information, please see DeltaQ’s Whole building modelling report.

Building-level CBA

The building-level CBA for Stringency Level 3 for the large office building archetypes (C5OL) for the climate zone that contains the capital city in each state is shown in table 5..[126]

126 Building-level CBA results have been estimated for each relevant Climate Zones for each state and territory, but are not reported.

5.8 Stringency Level 3 estimated costs and benefits — C5OL

Impact	NSW (CZ5) $ per m²	VIC (CZ6) $ per m²	QLD (CZ2) $ per m²	WA (CZ5) $ per m²	SA (CZ5) $ per m²	TAS (CZ7) $ per m²	ACT (CZ7) $ per m²	NT (CZ1) $ per m²
Avoided electricity network capacity costs	7.84	0.73	10.07	1.68	4.28	-12.21	-5.55	13.55
Avoided electricity wholesale costs	14.33	8.85	15.77	7.98	9.99	5.26	6.51	27.98
Avoided electricity network usage costs	7.79	9.12	10.71	19.77	18.14	3.37	5.24	9.21
Avoided electricity retail costs	4.50	2.80	5.48	4.41	4.86	-0.54	0.93	7.61
Electricity exported to grid	0.09	0.02	0.04	0.07	0.14	0.19	0.10	0.20
Avoided gas costs	0.76	3.04	0.22	0.79	0.82	12.38	8.67	0.00
Avoided GHG emissions - electricity	8.44	15.83	24.41	15.23	5.74	1.10	4.49	27.79
Avoided GHG emissions - exported electricity	0.10	0.23	0.11	0.17	0.06	0.03	0.12	0.23
Avoided GHG emissions - gas	1.59	5.14	0.54	1.53	1.37	15.55	18.01	0.00
Capital costs	-31.35	-36.68	-42.53	-31.35	-31.35	-40.34	-40.34	-44.30
Total	**14.09**	**9.08**	**24.81**	**20.29**	**14.05**	**-15.22**	**-1.83**	**42.26**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

The net benefits for all archetypes for each state and territory (capital city climate zone) are summarised in table 5.9. Detailed CBA results for each archetype are provided in appendix G.

Key findings from the building-level analysis are as follows:

- The proposed changes are estimated to deliver net benefits across all building archetypes.
- The net benefits for the three relevant archetypes (C3HL, C5OL and C9A) are slightly lower than for Stringency Level 2, and the others are the same.

5.9 Building-level net benefits for Stringency Level 3 by archetype

Building	NSW (CZ5) $ per m²	VIC (CZ6) $ per m²	QLD (CZ2) $ per m²	WA (CZ5) $ per m²	SA (CZ5) $ per m²	TAS (CZ7) $ per m²	ACT (CZ7) $ per m²	NT (CZ1) $ per m²
C3HL	16.72	34.31	59.90	23.63	19.87	37.16	37.13	101.36
C3HS	131.23	139.43	333.27	158.25	141.94	98.44	114.04	376.57
C5OL	14.09	9.08	24.81	20.29	14.05	-15.22	-1.83	42.26
C5OM	104.36	132.92	159.77	123.61	104.93	87.08	98.83	239.08
C5OS	93.97	154.96	119.47	109.57	94.84	100.55	101.93	231.55
C6RL	252.87	220.36	461.66	303.92	263.10	220.43	258.15	579.66
C6RS	354.68	415.49	582.86	415.13	355.98	240.64	283.54	926.73
C9A	-14.59	7.09	-16.44	-7.68	-13.05	-1.35	2.02	64.16
C9B	105.11	129.29	194.77	113.77	95.70	102.76	106.64	242.70
C9C [a]	77.12	222.73	183.27	101.33	84.67	69.62	85.53	232.35

Aged care facility (C9C) is modelled by DeltaQ as a small hospital (C9AS) because aged care building had very short HVAC running hours according to NCC 2022 schedules so wasn't an appropriate test bed.

Note: Estimates presented in present value terms based on: buildings constructed in 2025 assuming a 50-year life, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Saving in energy-related costs

Table 5.10 reports the estimated additional saving in energy-related costs for the three relevant modelled building archetypes in selected climate zone relevant to the capital city in each of the states and territories under Stringency Level 3 relative Stringency Level 2. As can be seen from the table, the savings are lower under Stringency Level 3 (as shown by negative numbers) in some cases. This is because savings in electricity consumption and related costs are lower with electrification readiness requirement.

5.10 Estimate additional savings in energy-related costs over building life under Stringency Level 3 relative to Stringency Level 2

Building	NSW (CZ5)	VIC (CZ6)	QLD (CZ2)	WA (CZ5)	SA (CZ5)	TAS (CZ7)	ACT (CZ7)	NT (CZ1)
	$ per m^2	$ per m^2	$ per m^2	$ per m^2	$ per m^2	$ per m^2	$ per m^2	$ per m^2
C3HL	-5.19	21.52	-3.61	-3.47	-5.79	25.75	20.96	9.59
C5OL	-1.16	-0.29	-0.89	-1.41	-2.28	-8.30	0.79	0.01
C9A	0.42	13.29	-1.91	0.83	0.02	5.80	5.53	11.34

[a] positive numbers indicate further cost savings, while negative numbers indicate less cost savings under Stringency Level 3 than Stringency Level 2.

Note: Estimates presented in present value terms based on: buildings constructed in 2025 assuming a 50-year life, using a discount rate of 5 per cent.

Source: CIE estimates based on DeltaQ modelling.

Change in capital-related costs

Table 5.11 reports estimated additional savings in capital-related costs over each building's life (assumed to be 50 years) in present value terms using a discount rate of 5 per cent under Stringency Level 3 relative to Stringency Level 2, for the three relevant archetypes.

5.11 Changes in capital-related costs over building life – Stringency Level 3

Building	1	2	3	4	5	6	7	8
	$/m^2	$/m^2	$/m^2	$/m^2	$/m^2	$/m^2	$/m^2	$/m^2
C3HL	-41.70	-42.25	-16.83	-28.12	-41.89	-32.55	-27.63	-43.60
C5OL	-10.66	-5.20	-8.04	-20.43	-7.66	-21.19	-22.28	-40.99
C9A	-40.01	-58.79	-10.50	-35.31	-57.19	-38.40	-30.55	-38.49

Note: A positive number indicates that costs are estimated to be lower under Stringency Level 3 than Stringency Level 2. A negative number indicates that capital-related costs are estimated to be higher (i.e. additional cost).

Source: DeltaQ modelling, CIE.

It can be seen that the three archetypes (C3HL, C5OL and C9A) relevant for electrification are all estimated to have higher construction costs under Stringency

Level 3 than under Stringency Level 2 due to costs associated with electrification and/or electrification readiness.

This universal increase in capital costs together with some reduction in energy-related cost savings reported above explains lower net benefit under Stringency Level 3 than Stringency Level 2 for the three archetypes.

Mandatory electric vehicle charging

The estimated cost of providing EV charging facilities per building are summarised in table 5., with further details provided below.

5.12 Estimated cost of EV charging per building — summary

Building tyoe	Unit cost per charger [a]	Number of chargers [b]	Total [a]
	$	No.	$
Hotel (Class 3)	15,223	7	106,559
Office building (Class 5)	15,223	5	76,114
Warehouse (Class 7b)	15,505	10	155,045
Laboratory (Class 8(1))	15,505	10	155,045
Factory (Class 8(2))	15,505	10	155,045
Hospital (Class 9a)	15,223	30	456,683
Aged care facility (Class 9c)	15,223	30	456,683

[a] Present value calculated over 50-year life of building, using a discount rate of 5 per cent. [B] Assumes 10-20 per cent of car park spaces are installed with chargers.

Source: See tables 5.14 and 5.15 below.

These costs do not include those associated with obtaining additional electrical capacity. The EV charging provisions are designed to exploit spare capacity, which is often used for only short periods within a year. As such, EV charging facilities would be configured to switch off in the event that the building is approaching capacity meaning that EV charging would not be available in peak periods. However, this is not expected to significantly reduce availability of EV charging as peak capacity typically occurs for short periods.

Internal car parks

In present value terms, the unit cost of EV charging equipment in an internal carpark is estimated at $15,223 per charger over the life of the building (50 years) using a discount rate of 5 per cent (table 5.). This includes:

- Upfront costs for equipment and installation of around $3 849,[127] which we assume needs to be replaced every 20 years (in line with the assumptions about other equipment, and using the same treatment of residual values);
- Annual maintenance costs of $500, which is $9 584 in present value terms over the 50-year life of the building, using a discount rate of 5 per cent.

5.13 Unit cost of charger installation — Internal car parks

Cost item	Upfront cost $	Annual costs $	Present value over building life[a] $
Supply, installation and commissioning (including LMS)	2,988	0	4,377
Supply, install data cable	586	0	858
Billing platform	275	0	403
Maintenance	0	500	9,584
Total	**3,849**	**500**	**15,223**

[a] Present value calculated over 50-year life of the building, using a discount rate of 5 per cent.

Source: DeltaQ, NCC 2025 Energy Efficiency — Advice on the technical basis, Initial Measures Development: Electrical Services Report, Prepared for the Australian Building Codes Board, 26 September 2023, pp. 87-90, CIE.

The internal car park costings are relevant for:

- Hotels (Class 3)
- Office buildings (Class 5)
- Hospitals (Class 9a)
- Aged care facilities (Class 9c).

External car parks

Estimates prepared for ABCB are based on an external car park with 100 car spaces, with 10 EV chargers (i.e. 10 per cent of total spaces). The cost of installing EV charging equipment were estimated at $42 000. Annual maintenance cost is assumed to be the same as internal car parks at $500 per charger. This estimate would be relevant to:

- Warehouses (Class 7b)
- Laboratories (Class 8(1))
- Factories (Class 8(2)).

Assuming that all equipment (except for the 5 steel posts) need to be replaced after 20 years (consistent with the assumptions for building equipment), this implies:

- a total cost of around $155 045 per building in present value terms over the life of the building (50 years), using a discount rate of 5 per cent;
- an average cost of $15 505 per charger (in present value terms).

127 DeltaQ, *NCC 2025 Energy Efficiency — Advice on the technical basis, Initial Measures Development: Electrical Services Report*, Prepared for the Australian Building Codes Board, 26 September 2023, p. 87-90

5.14 Unit cost of charger installation — External car parks

Cost item	One-off costs	Replaceable component	Present value[a]	Present value per charger[b]
	$	$	$	$
110m internal cable run, parts and labour	0	6,000	8,789	879
Distribution board	0	5,000	7,325	732
Trenching, conduit and underground cable	0	2,500	3,662	366
EVSE	0	23,500	34,425	3,443
Steel support posts	5,000	0	5,000	500
Maintenance	0	5,000[c]	95,844	9,584
Total	**5,000**	**42,000**	**155,045**	**15,505**

[a] Calculated over the life of the building (50 years), using a discount rate of 5 per cent. [B] Based on 10 chargers installed in a car park with 100 car spaces (i.e. EV charging in 10 per cent of car spaces). [C] Annual for 10 chargers.

Source: Estimates prepared for ABCB.

Benefits

The approach to estimating the benefits of greater provision of charging facilities in car parks associated with commercial buildings is based on communitywide benefits based on the proportion of destinations that have charging facilities (rather than aggregating up from building-level benefits). As such, the aggregate benefits are estimated in chapter 6.

6 *Aggregate impacts*

The building level impacts presented in the previous chapter are aggregated into state and national results, using the commercial building projections by Strategy.Policy.Research (SPR) for Department of Climate Change, Energy, the Environment and Water (DCCEEW),[128] and taking into account of solar PV and EV charging in the baseline.

Summary of aggregate impacts

Table 6.1 summarises the CBA results for each of the 3 options (compared to current practice under the current code). All costs and benefits are expressed in net present value terms (using a discount rate of 5 per cent) over the life (assumed to be 50 years) of all commercial buildings to be constructed over the 10-year period from 2025 to 2034. Benefit-cost ratios are not reported in the table because there are capital cost savings under Stringency Level 1.

Key findings are as follows:

- All options under consideration are estimated to deliver significant net benefits (relative to current NCC requirements) indicating a strong case to update the NCC.
- Option 1 is estimated to deliver net benefits of around **$6.7 billion** in net present value terms.
  - The proposed changes to the minimum energy efficiency standards are estimated to deliver net benefits of around **$8.5 billion**.
  - These benefits are partly offset by the EV charging requirements, which are estimated to impose a net cost of around **$1.7 billion** (this applies across all options).
- Option 2 is estimated to deliver the highest net benefits of all the options — around **$11 billion** in net present value terms — indicating this is the preferred option from a CBA perspective.
  - The building energy requirements — including upgrading the minimum energy efficiency requirements (as for Stringency Level 1) and mandatory rooftop solar — is estimated to deliver net benefits of around **$12.7 billion**. This

128 SPR (Strategy.Policy.Research) 2022, *Commercial Building Baseline Study 2022*, final report for Department of Climate Change, Energy, the Environment and Water, August 2022, https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022

indicates that the mandatory requirement to install rooftop solar is estimated to deliver an incremental benefit over and above the costs.

  – These benefits are partly offset by the net costs of **$1.7 billion** associated with mandatory EV charging requirements.

- The estimated impacts of Option 3 are slightly lower than Option 2 at around **$10.6 billion**.
  – The Stringency Level 3 building energy requirements — including: upgrades to the minimum energy efficiency requirements, mandatory rooftop solar and measures to facilitate the shift to net zero buildings — are estimated to be slightly lower than Stringency Level 2 at around **$12.4 billion**. This indicates that the incremental impact of the net zero buildings measures is broadly neutral (currently estimated as a small net cost).
  – These benefits are partly offset by the net costs of **$1.7 billion** associated with the mandatory EV charging requirements.

6.1 Estimated impacts of proposed options

Impact	Option 1 $ million	Option 2 $ million	Option 3 $ million
Building energy impacts			
Avoided electricity network capacity costs	1,168.76	1,835.93	1,811.55
Avoided electricity wholesale costs	2,079.18	3,702.37	3,644.44
Avoided electricity network usage costs	1,757.91	3,539.61	3,515.61
Avoided electricity retail costs	750.88	1,361.69	1,345.74
Electricity exported to grid	71.94	446.50	446.81
Avoided gas costs	-16.95	-16.95	61.04
Avoided GHG emissions – electricity	1,799.92	3,420.84	3,394.01
Avoided GHG emission — exported electricity	130.08	778.40	779.29
Avoided GHG emissions – gas	-33.28	-33.28	119.63
Capital costs	743.02	-2,335.34	-2,746.26
Total building energy impacts	**8,451.44**	**12,699.77**	**12,371.86**
Mandatory EV charging			
Improved access to destination charging	1,560.62	1,560.62	1,560.62
Mitigation of climate change	84.06	84.06	84.06
Mitigation of air pollution	12.10	12.10	12.10
EV charging equipment installation and maintenance	-3,396.79	-3,396.79	-3,396.79
Total EV charging	**-1,740.01**	**-1,740.01**	**-1,740.01**
Total	**6,711.43**	**10,959.76**	**10,631.85**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

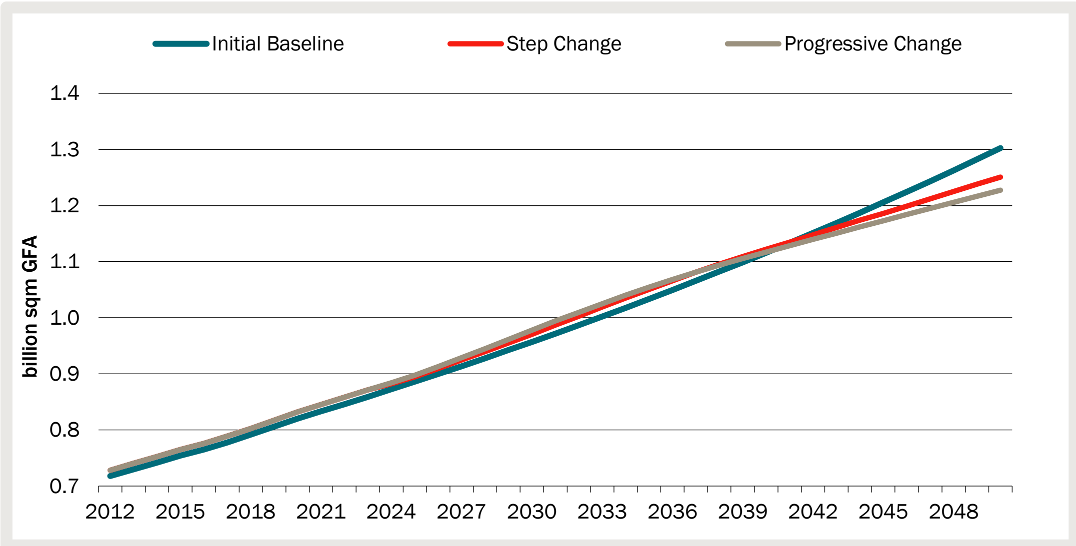
Commercial building projections

The aggregate impacts are based on the building-level costs and benefits (per square metre of floor space) multiplied by projected construction of new buildings over the period from 2025 to 2034.

The most recent, comprehensive projection of commercial buildings has been the Commercial Buildings Energy Consumption baseline study conducted by SPR for DCCEEW in 2022.[129] The study has provided end of financial year commercial building stock projections up to 2050, with granular details of regions, climate zones, and commercial building classifications. It provides three projection scenarios – the initial base case projection, and the two updated projections corresponding to AEMO's Step Change and Progress Change scenarios (chart 6.2).

We use the Step Change scenario as the basis for the projection of new commercial buildings because the Step Change scenario is identified as the most likely scenario by AEMO.[130]

6.2 Commercial building stock projections



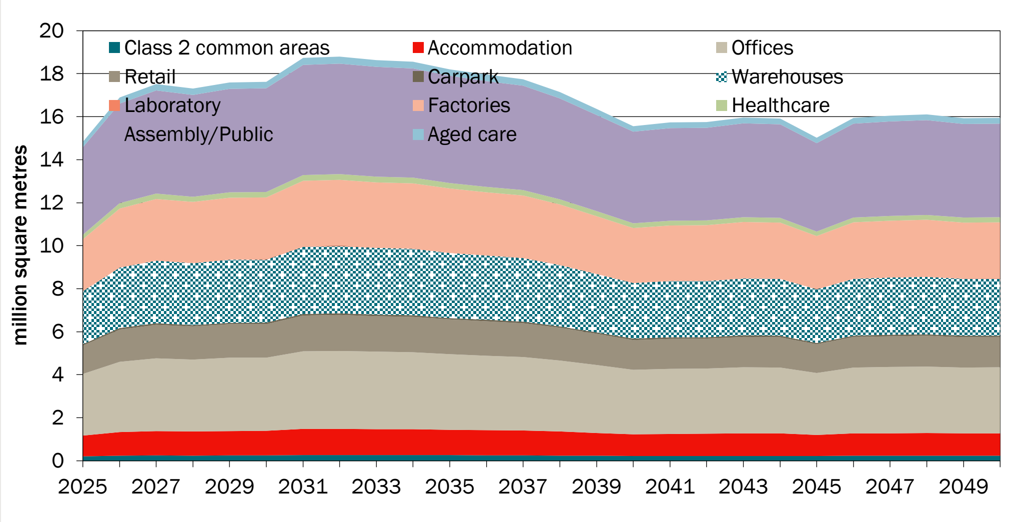
Data source: SPR (2022).

It was projected that, under the Step Change scenario, new construction of commercial buildings will be 14.83 million m^2 in 2025, growing to a peak of about 18.8 million m^2 in 2032, before falling to 15.94 million m^2 by 2050. The largest components of new buildings are assembly/public building (Class 9b), offices (Class 5), warehouses (Class 7b), factories (Class 8(2)) and retail (Class 6) (chart 6.3).

129 SPR (2022), op. cit.

130 AEMO 2022, *AEMO releases 30-year electricity market roadmap*, 30 June 2022, https://aemo.com.au/newsroom/media-release/aemo-releases-30-year-electricity-market-roadmap

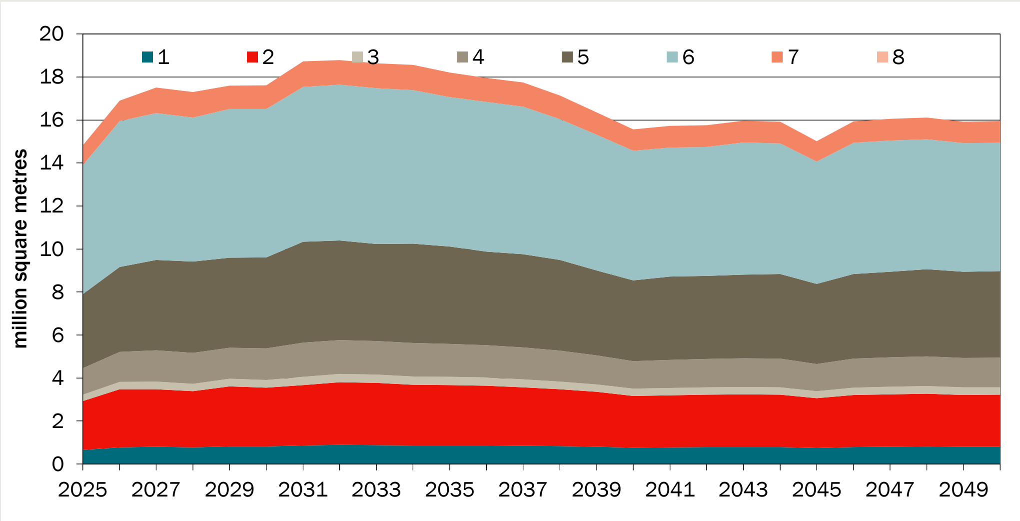
6.3 New construction of commercial buildings: Step change



Data source: SPR (2022).

Chart 6.4 provides a breakdown of new commercial building construction by climate zone (CZ). The majority of new constructions, approximately 40 per cent, are situated in CZ 6, followed by CZ 5, which accounts for approximately 25 per cent, and CZ 2 with around 15 per cent. Notably, there are no new construction of commercial buildings in CZ 8.

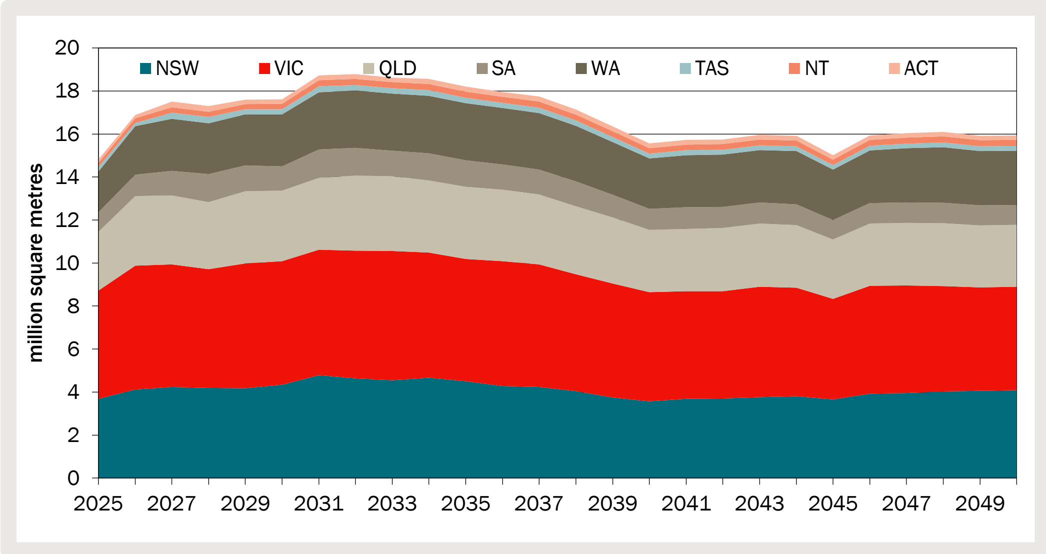
6.4 New construction of commercial buildings by climate zone



Data source: SPR (2022).

Chart 6.5 reports the distribution of new commercial building construction by state and territory. Victoria leads with the largest share, exceeding 30 per cent, followed by NSW at around 25 per cent, Queensland at around 18 per cent, and WA with a range of 13-16 per cent.

6.5 New construction of commercial buildings by jurisdiction



Data source: SPR (2022).

For refurbishments, it was estimated that around 0.68 per cent of the existing building stock may be impacted each year.[131] This suggests that refurbishment will be about 8.5 million square metres by 2050.

Building energy impacts

The aggregate impacts of the building energy measures across each of the 3 stringencies is discussed below.

Aggregate building energy impacts by state and territory

The aggregate building energy impacts (excluding the requirement for mandatory EV charging, which is discussed below) are estimated by aggregating up from the building-level (on a square metre basis) up to the state and national level using the above building projections.

Stringency Level 1: Cost-effective energy efficiency without mandated on-site PV

The aggregate building energy impacts for each state and territory under Stringency Level 1 are summarised in table 6.6. At the national level, the proposed increase in the minimum energy efficiency standards is estimated to deliver a net benefit of around **$8.5 billion** in net present value terms over the 50-year life of buildings constructed over the 10 year period from 2025, using a discount rate of 5 per cent.

131 CIE 2018, *Decision Regulation Impact Statement: Energy Efficiency of Commercial Buildings*, p.188

6.6 Estimated impacts by state/territory — Stringency Level 1

Impact	NSW $ million	VIC $ million	QLD $ million	WA $ million	SA $ million	TAS $ million	ACT $ million	NT $ million	Total $ million
Avoided network capacity costs	347.3	256.5	365.9	48.4	49.6	40.1	18.3	42.6	1,168.8
Avoided wholesale costs	511.1	550.8	574.4	197.3	114.8	27.7	25.0	78.1	2,079.2
Avoided network usage costs	244.1	497.1	359.7	440.9	162.5	11.1	17.0	25.5	1,757.9
Avoided retail costs	165.4	195.7	195.0	103.0	49.0	11.8	9.0	21.9	750.9
Electricity exported to grid	23.0	11.8	16.5	8.5	7.9	2.0	1.2	0.9	71.9
Avoided gas costs	-4.0	-8.5	-0.6	-1.9	-1.2	-0.7	-0.1	0.0	-16.9
Avoided GHG emissions – electricity	139.3	659.9	613.0	274.8	43.3	3.0	6.0	60.6	1,799.9
Avoided GHG emissions — electricity exported	11.2	73.1	25.4	15.5	3.2	0.3	0.6	0.8	130.1
Avoided GHG emissions – gas	-9.1	-15.2	-1.6	-3.9	-2.2	-0.9	-0.3	0.0	-33.3
Capital costs	160.8	118.3	264.3	129.8	52.1	0.6	-0.7	17.9	743.0
Total	**1,589.1**	**2,339.4**	**2,412.0**	**1,212.4**	**479.0**	**95.2**	**76.1**	**248.3**	**8,451.4**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Under Stringency Level 1:

- There would be a significant reduction in electricity consumption and therefore electricity-related costs, including reduced GHG emissions.
- There would also be a small increase in electricity exported to the grid — although there is no mandatory requirement for rooftop solar under Stringency Level 1, our base case assumes some voluntary uptake of solar. The increase in the minimum energy efficiency standards would result in these buildings consuming less energy, meaning more of the energy generated from the rooftop solar would be available for export.
- Electricity-related savings would be partly offset by a relatively small increase in gas consumption and a corresponding increase in GHG emissions.
- It is estimated that the improvements in energy efficiency could be achieved with lower capital-related costs than under the base case.

Stringency Level 2: Cost-effective energy efficiency standards with mandated on-site PV

The aggregate impacts of the proposed increase in the minimum energy efficiency standards and mandatory rooftop solar by state and territory are summarised in table 6.7. At the national level, the proposed increase in the minimum energy efficiency standards is estimated to deliver a net benefit of around **$12.7 billion** in net present value terms over the 50-year life of buildings constructed over the 10-year period from 2025, using a discount rate of 5 per cent.

6.7 Estimated impacts by state/territory — Stringency Level 2

Impact	NSW $ million	VIC $ million	QLD $ million	WA $ million	SA $ million	TAS $ million	ACT $ million	NT $ million	Total $ million
Avoided network capacity costs	540.8	486.9	515.1	71.8	77.3	53.5	26.2	64.3	1,835.9
Avoided wholesale costs	935.6	1,114.5	901.5	336.5	189.8	53.0	48.2	123.2	3,702.4
Avoided network usage costs	500.5	1,191.3	612.1	816.3	315.9	24.4	39.1	40.0	3,539.6
Avoided retail costs	296.5	418.9	304.3	183.7	87.5	19.6	17.0	34.1	1,361.7
Value of electricity exported to grid	135.5	65.4	110.3	58.6	44.9	12.5	7.6	11.8	446.5
Avoided gas costs	-4.0	-8.5	-0.6	-1.9	-1.2	-0.7	-0.1	0.0	-16.9
Avoided GHG emissions – electricity	270.4	1,402.7	1 059.3	492.6	81.7	6.2	12.8	95.0	3,420.8
Avoided GHG emissions — electricity exported	64.5	414.5	169.5	96.1	17.9	1.7	3.7	10.6	778.4
Avoided GHG emissions – gas	-9.1	-15.2	-1.6	-3.9	-2.2	-0.9	-0.3	0.0	-33.3
Capital costs	-589.0	-895.0	-306.0	-290.3	-150.8	-39.5	-38.6	-26.0	-2,335.3
Total	**2,141.7**	**4,175.4**	**3,364.0**	**1,759.4**	**660.8**	**129.8**	**115.7**	**352.9**	**12,699.8**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Compared with Stringency Level 1, capital costs are higher (i.e. there is net increase in capital costs) reflecting the additional costs associated with installation of rooftop solar.

However, these costs are outweighed by significant additional electricity-related savings (including GHG emissions), due to reduced consumption of electricity from the grid and, to a lesser extent, increased export of electricity to the grid. Consumption of gas is unaffected by mandatory rooftop solar (relative to Stringency Level 1).

Stringency Level 3: Least cost net zero carbon ready buildings

Details of the state-level impacts for Stringency Level 3 is summarised in table 6.8. At the national level, net benefits are estimated at around $13 billion, slightly lower than the net benefits of Stringency Level 2. This indicates that the incremental impact of Stringency Level 3 (compared with Stringency Level 2) is slightly negative (assuming dual fuel buildings are not required convert to fully electric in the future).

The incremental impact of Stringency Level 3 is relatively modest (compared to the other elements of the proposal) because only 3 of the 10 archetypes modelled (the large hotel, the large office building and large hospital ward) are dual fuel buildings.

6.8 Estimated impacts by state/territory — Stringency Level 3

Impact	NSW $ million	VIC $ million	QLD $ million	WA $ million	SA $ million	TAS $ million	ACT $ million	NT $ million	Total $ million
Avoided network capacity costs	533.8	478.3	513.4	71.3	77.0	49.3	24.2	64.3	1,811.6
Avoided wholesale costs	918.2	1,091.0	897.3	332.6	185.2	50.3	46.3	123.5	3,644.4
Avoided network usage costs	496.4	1,182.1	610.9	811.3	313.1	23.6	38.2	40.1	3,515.6
Avoided retail costs	292.3	412.7	303.2	182.3	86.3	18.5	16.3	34.2	1,345.7
Value of electricity exported to grid	135.6	65.5	110.3	58.6	44.9	12.5	7.6	11.8	446.8
Avoided gas costs	14.9	29.1	1.6	6.2	2.8	4.1	2.1	0.3	61.0
Avoided GHG emissions – electricity	267.4	1,386.0	1,057.3	488.7	80.9	6.0	12.5	95.3	3,394.0
Avoided GHG emissions — electricity exported	64.5	415.3	169.5	96.2	17.9	1.7	3.7	10.6	779.3
Avoided GHG emissions – gas	34.4	51.9	4.5	13.0	5.1	5.3	4.9	0.5	119.6
Capital costs	-686.7	-1,043.4	-371.2	-346.5	-177.0	-45.1	-43.9	-32.5	-2,746.3
Total	**2,070.8**	**4,068.4**	**3,296.8**	**1,713.6**	**636.3**	**126.1**	**111.9**	**348.0**	**12,371.9**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Consistent with the objective of these provisions, there is a reduction in the costs associated with gas consumption (including GHG emissions) reflecting a shift towards fully-electric buildings (i.e. 50 per cent of buildings are assumed to choose the 'electrify now' option). However, this is offset by a corresponding increase in electricity consumption.

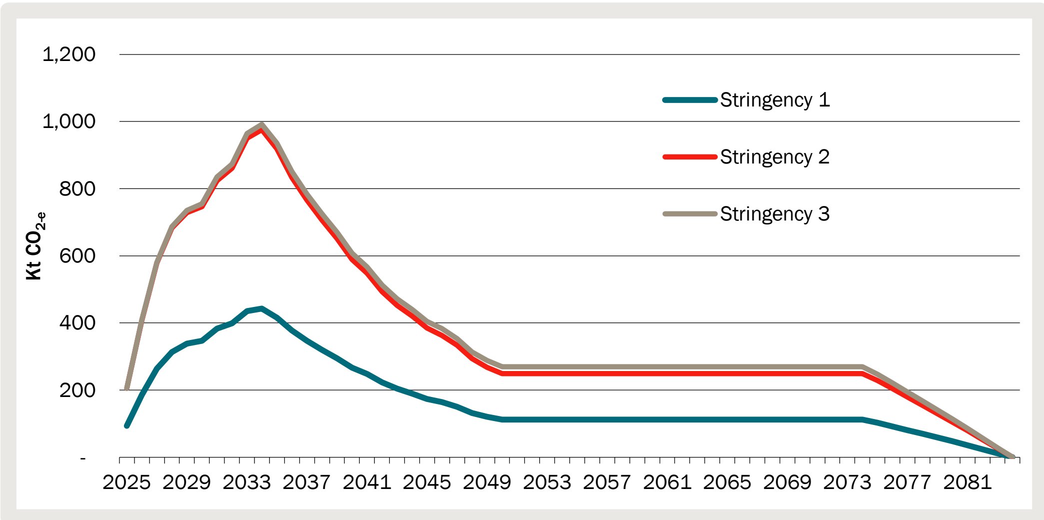
There is also an increase in aggregate costs, reflecting the additional costs associated of complying with the least cost net zero emissions requirements for the relevant buildings.

Aggregate reduction in GHG emissions

Avoided GHG emissions across the different stringency levels are shown in chart 6.9.

- Under all stringency levels:
  - avoided GHG emissions initially increases as the effect of the increasing number of buildings built under the new code requirements outweighs the impact of declining carbon intensity of electricity supply
  - as the number of buildings built under the new codes reaches a peak (at the end of the 10-year regulatory period), avoided GHG emissions starts to decline as the grid continues to decarbonise
  - avoided GHG emission then levels off as the GHG-intensity of electricity supply reaches its minimum and then tails of to zero as the buildings built under the new code are assumed to reach the end of their life.
- Avoided GHG emissions are significantly higher for Stringency Levels 2 and 3, compared with Stringency Level 1. However, there is minimal difference between Stringency Level 2 and Stringency Level 3.

6.9 Avoided GHG emissions



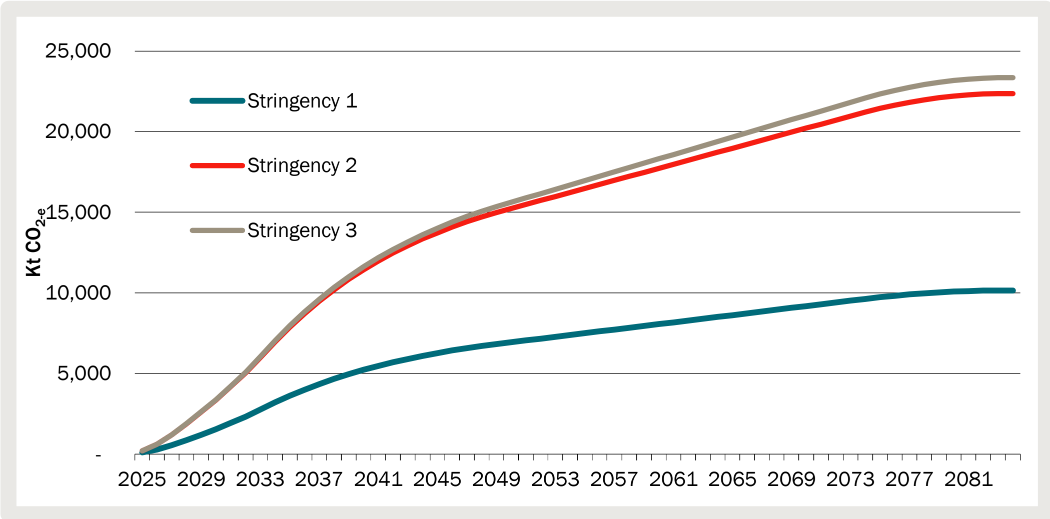
Data source: CIE based on DeltaQ modelling.

On a cumulative basis (see chart 6.10), avoided GHG emissions are estimated at around:

- 10.1 Mt $CO_{2\text{-}e}$ for Stringency Level 1
- 22.4 Mt $CO_{2\text{-}e}$ for Stringency Level 2
- 23.3 Mt $CO_{2\text{-}e}$ for Stringency Level 3.

The cumulative difference between Stringency Levels 2 and 3 across the whole period is therefore less than 1 Mt $CO_{2\text{-}e}$.

6.10 Cumulative avoided GHG emissions



Data source: CIE based on DeltaQ modelling.

Scenario analysis

To more fully understand the results and the extent to which they are sensitive to particular assumptions, extensive sensitivity and scenario analysis is undertaken below.

Future electrification

A key uncertainty relates to the possibility that dual-fuel buildings will be required to convert to fully electric at some point in the future.

As most of the buildings that will be constructed during the 2025-2034 regulatory period will still be operating by 2050, this will be necessary (together with decarbonisation of the electricity grid) to achieve net zero emission buildings, consistent with economywide net zero commitments.

However, as the policy or market mechanisms to encourage or force dual-fuel buildings to convert to fully electric buildings are currently not clear, the central case assumes that dual-fuel buildings will continue to operate with both gas and electricity.

That said, it is also plausible that dual fuel buildings will be forced to convert to fully electric at some point in the future. Policy and market mechanisms that could force dual-fuel buildings to convert in the future include:

- a policy requirement from the relevant state government;
- inability to source gas (at a competitive price) in the future;
- inability to make a like-for-like replacement of the gas-fired boiler in the future.

As a shift towards fully electric buildings (either immediately or at some point in the future), a key rationale behind Stringency Level 3, it is important to test the impacts of each of the stringencies under a scenario where dual-fuel buildings convert to fully electric in the future.

As the mechanism that prompts dual fuel buildings to electrify (i.e. convert to fully electric) or the timing is not known, we assume that the conversion occurs at the time that the gas boiler needs to be replaced. For consistency with the assumed life of HVAC equipment used elsewhere, we assume this occurs after 20 years.

A key finding under this scenario, the net benefits of Stringency Level 3 exceed Stringency Level 2, implying Stringency Level 3 is the preferred option (see table 6.11). This finding is relatively insensitive to the assumed timing of the future conversion. This finding demonstrates the results are highly dependent on future developments which cannot be known with certainty.

6.11 Future electrification scenario — summary

Impact	Stringency Level 1 $ million	Stringency Level 2 $ million	Stringency Level 3 $ million
Avoided network capacity costs	1,164.5	1,831.8	1,816.9
Avoided wholesale costs	2,065.1	3,688.3	3,654.4
Avoided network usage costs	1,747.7	3,529.4	3,518.5
Avoided retail costs	746.6	1,357.4	1,348.5
Electricity exported to grid	71.9	446.5	446.8
Avoided gas costs	-11.5	-11.5	41.4
Avoided GHG emissions – electricity	1,795.2	3,416.1	3,396.1
Avoided GHG emissions – exported electricity	130.1	778.4	779.3
Avoided GHG emissions – gas	-20.5	-20.5	73.6
Capital costs	736.1	-3,731.7	-2,945.2
Total building energy impacts	**8,425.2**	**11,284.3**	**12,130.3**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Where the future scenario in relation to future electrification is not known, the CBA results can be expressed as an 'expected value'. The expected value is the probability-weighted average of the different scenarios.

Based on the modelling results, the provisions to achieve net zero buildings at least cost 'breaks even' (implying the costs are equal to the benefits), where the probability that dual-fuel buildings are required to convert to fully electric in the future is around **28 per cent** (where all other assumptions are held constant, including: 50 per cent of buildings would choose the dual fuel offset; and 50 per cent would choose to 'electrify now'; and all dual fuel buildings would be required to convert to fully electric 20 years after construction).

6.12 Break-even future electrification probability

Future scenario	Probability of scenario occurring	Stringency Level 2 – net impact	Stringency Level 3 – net impact	Incremental impact of Stringency Level 3
	Per cent	$ million	$ million	XXXXX
No future electrification	72%	12,699.8	12,371.9	-327.9
Future electrification	28%	11,284.3	12,130.3	846.0
Expected outcome		**12,304.4**	**12,304.4**	**0.0**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent. Assumes that under Stringency Level 3, 50 per cent of building choose the dual-fuel offset; and 50 per cent choose to electrify now. Also assumes electrification occurs 20 years after construction.

Source: CIE based on DeltaQ modelling.

This implies the following:

- If the probability that dual fuel buildings will be required to convert to fully electric when the gas boiler requires replacement is considered greater than 28 per cent, the provisions to achieve net zero at least cost would deliver a net benefit.
- If the probability that dual fuel buildings will be required to convert to fully electric when the gas boiler requires replacement is considered less than 28 per cent, the provisions to achieve net zero at least cost would deliver a net cost.

No uptake of solar in the base case

Although our assumption about the uptake of solar in the base case was based on the best available information,[132] this was based on a limited sample size, and it is not clear to what extent the sample is representative of all buildings at the national level.

To provide an indication of the aggregate net impacts of difference between the NCC 2022 minimum standards and the proposed 2025 options, table 6.13 summarises the CBA results under the scenario where there is no voluntary uptake of rooftop solar. Under this scenario, the impacts of the proposed changes are significantly higher for Stringency Level 2 and Stringency Level 3 (compared with the central case CBA results); note that this reflects the (incorrect) attribution of the impacts of voluntary uptake of rooftop solar to the proposed changes to the NCC.

Although the magnitude of the net benefits from Scenario 2 and Scenario 3 are greater, the ordering of benefits does not change.

6.13 No voluntary uptake of rooftop solar in base case — summary

Impact	Stringency Level 1	Stringency Level 2	Stringency Level 3
	$ million	$ million	$ million
Avoided network capacity costs	1,233.7	2,853.8	2,829.4
Avoided wholesale costs	2,189.7	6,028.8	5,970.9
Avoided network usage costs	1,902.4	6,136.0	6,112.0

132 Strategy.Policy.Research. *Research report: use of renewable energy to trade-off energy efficiency requirements in Section J of the National Construction Code*, Prepared for the Department of Industry, Science, Energy and Resources, 20 January 2022, p. 4.

Impact	Stringency Level 1 $ million	Stringency Level 2 $ million	Stringency Level 3 $ million
Avoided retail costs	798.9	2,252.8	2,236.8
Electricity exported to grid	0.0	929.0	929.3
Avoided gas costs	-17.0	-17.0	61.0
Avoided GHG emissions – electricity	1,930.0	5,764.0	5,737.2
Avoided GHG emissions – exported electricity	0.0	1,607.6	1,608.5
Avoided GHG emissions – gas	-33.3	-33.3	119.6
Capital costs	743.0	-6,620.4	-7,031.3
Total building energy impacts	**8,747.4**	**18,901.4**	**18,573.5**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Realisation rate

The central case for the CBA assumes full realisation. However, the extent to which modelled energy savings are realised in practice was identified as a key issue for the CRIS.

Although there is some evidence that modelled energy savings are not fully realised, the extent of the discrepancy between modelled and actual outcomes is not clear. Nevertheless, we test the extent to which this issue affects the CBA outcome using realisation rate of:

- 50 per cent (table 6.14), and
- 75 per cent (table 6.15).

6.14 CBA results using realisation rate of 50 per cent

Impact	Stringency Level 1 $ million	Stringency Level 2 $ million	Stringency Level 3 $ million
Avoided network capacity costs	584.38	917.97	905.78
Avoided wholesale costs	1 039.59	1 851.18	1 822.22
Avoided network usage costs	878.96	1 769.81	1 757.81
Avoided retail costs	375.44	680.84	672.87
Electricity exported to grid	35.97	223.25	223.40
Avoided gas costs	- 8.47	- 8.47	30.52
Avoided GHG emissions – electricity	899.96	1 710.42	1 697.01
Avoided GHG emissions – exported electricity	65.04	389.20	389.65
Avoided GHG emissions – gas	- 16.64	- 16.64	59.81
Capital costs	743.02	-2 335.34	-2 746.26
Total building energy impacts	**4 597.23**	**5 182.21**	**4 812.80**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

6.15 CBA results using realisation rate of 75 per cent

Impact	Stringency Level 1 $ million	Stringency Level 2 $ million	Stringency Level 3 $ million
Avoided network capacity costs	876.6	1,377.0	1,358.7
Avoided wholesale costs	1,559.4	2,776.8	2,733.3
Avoided network usage costs	1,318.4	2,654.7	2,636.7
Avoided retail costs	563.2	1,021.3	1,009.3
Electricity exported to grid	54.0	334.9	335.1
Avoided gas costs	-12.7	-12.7	45.8
Avoided GHG emissions – electricity	1,349.9	2,565.6	2,545.5
Avoided GHG emissions – exported electricity	97.6	583.8	584.5
Avoided GHG emissions – gas	-25.0	-25.0	89.7
Capital costs	743.0	-2,335.3	-2,746.3
Total building energy impacts	**6,524.3**	**8,941.0**	**8,592.3**

Note: Estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Although the magnitude of the net benefits is relatively sensitive to lower (but broadly plausible) realisation rates, the key conclusions are broadly unchanged. In particular:

- all stringency levels are estimated to deliver net benefits (compared to current arrangements)
- the ordering of the options is unchanged: Stringency Level 2 is estimated to deliver the largest net benefits, following by Stringency Level 3 and Stringency Level 1.

Other sensitivity testing

We also tested the sensitivity of the CBA results to various other input parameters and assumptions as set out in table 6.16.

6.16 Alternative assumptions for sensitivity testing

Parameter/assumption	Central case	Alternative case 1	Alternative case 2
Regulatory period	10 years (2025-2034)	20 years	
Discount rate	5 per cent	2 per cent	7 per cent
Building life	50 years	40 years	60 years
Equipment life	20 years	15 years	
Social cost of carbon	2.0% discount rate	1.5% discount rate	2.5% discount rate
Avoided retail costs	15% (based on retail margin).	No avoided retail costs (all retail costs are fixed).	

Parameter/assumption	Central case	Alternative case 1	Alternative case 2
Realisation rate	100% (due to lack of evidence).	50% applied to aggregate energy savings (rather than just the energy efficiency component).	75% applied to aggregate energy savings (rather than just the energy efficiency component).
Share of relevant buildings choosing dual fuel offset option (Stringency Level 3)	50%	100%	100% with future electrification
Share of relevant buildings choosing 'electrify now' option (for Stringency Level 3)	50%	100%	100% with dual fuel offset
Learning rate[a]	No future learning rate	Future costs decrease by 20% over 10 years (1.8% per year)	Future PV costs decrease by 10% over 10 years. Applied as a reduction in plant costs of 5% over 10 years (0.5 per cent per year)

[a] Based on advice from the paper by Hutley (2023).

Source: CIE.

The CBA results for each stringency under the alternative assumptions set out in table 6.16 are summarised in table 6.17. Unless otherwise stated (i.e. explicitly varied to test the sensitivity of the results), the CBA results are expressed in net present value terms over the 50-year life of all buildings constructed over the 10-year regulatory period from 2025 to 2034. The stringency with the highest net present value under each of the alternative assumptions are highlighted in blue.

6.17 CBA results under different sensitivity assumptions — net present value

Sensitivity scenario	Stringency Level 1 $ million	Stringency Level 2 $ million	Stringency Level 3 $ million
Central case	8,451	12,700	12,372
Regulatory period (20 years)	13,158	19,543	19,036
Discount rate (2 per cent)	15,044	23,557	23,175
Discount rate (7 per cent)	6,284	9,178	8,881
Building life (40 years)	8,027	12,064	11,744
Building life (60 years)	8,714	13,094	12,762
Equipment life (15 years)	8,436	12,207	11,826
Social cost of carbon (1.5%)	9,614	15,251	14,995
Social cost of carbon (2.5%)	7,745	11,149	10,775
Avoided retail costs (no avoided retail costs)	7,701	11,338	11,026
Dual fuel offset option (100%)	8,451	12,700	12,752
Dual fuel offset option (100% with future electrification in the base case)	8,425	11,284	11,493
Electrify now option (100%)	8,451	12,700	11,580

Sensitivity scenario	Stringency Level 1 $ million	Stringency Level 2 $ million	Stringency Level 3 $ million
Electrify now option (100% with future electrification in the base case)	8,425	11,284	12,505
Solar PV learning rate (1.8% per year)	8,451	13,034	12,709
Heat pump learning rate (0.5% per year applied to all plant)	8,458	12,706	12,386

Note: Unless stated otherwise, estimates presented in net present value terms over an assumed 50-year life of all buildings constructed over the 10 year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Key findings from the sensitivity testing are as follows.

- Under all alternative assumptions, all stringencies are estimated to deliver a net benefit relative to NCC 2022. This suggests that the case for change is relatively robust.
- Under most alternative assumptions, Stringency Level 2 is estimated to deliver the highest net benefits, consistent with the central case. The key exceptions where the net benefits are higher for Stringency Level 3 are:
  - all scenarios involving future electrification, and
  - where all buildings choose the dual fuel offset option (although the estimates do not take into account any aesthetic costs associated with ground-mounted solar).
- The magnitude of the CBA results is most sensitivity to:
  - The choice of discount rate.
  - The realisation rate — as discussed above, there is some evidence that modelled energy efficiency benefits are not (on average) fully realised, although there is no reliable evidence on the extent to which actual energy savings fall short of modelled outcomes. This suggests that the true net benefits may be somewhat lower than has been estimated. That said, all stringencies are estimated to deliver a net benefit even under a pessimistic scenario where only 50 per cent of the benefits are realised.

Mandatory electric vehicle charging

The proposed mandatory electric vehicle charging requirements are estimated to impose a net loss on the community of around $1.7 billion in net present value terms over the 50-year life of buildings constructed over the 10-year period from 2025, using a discount rate of 5 per cent (table 6.18). Details are provided below.

6.18 Net impact of proposed mandatory electric vehicle charging requirements

Impact	Estimate $ million
Improved access to destination charging	1,560.6

Impact	Estimate $ million
Mitigation of climate change	84.1
Mitigation of air pollution	12.1
EV charging equipment installation and maintenance	-3,396.8
Total	**-1,740.0**

Note: Estimates presented in net present value terms over the (assumed) 50 years life of buildings constructed over the 10-year period from 2025 to 2034, using a discount rate of 5 per cent.

Source: CIE estimates.

Estimated benefits

Approach

As discussed in chapter 4, there are four components to the benefits of mandatory EV charging:

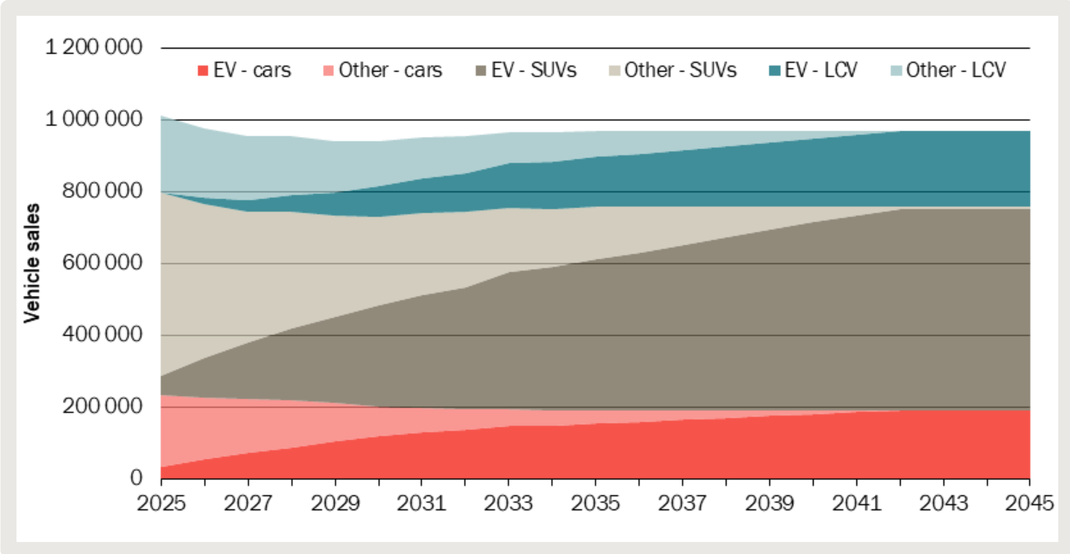
- Improved access to destination charging for EV drivers:
  - who are EV drivers under both the base case and the policy options, and
  - who would be induced to drive an EV by the policy options.
- mitigation of climate change due to reduced GHG emissions from the substitution from internal combustion vehicles to EVs induced by the policy options, and
- mitigation of the health impacts of air pollution from the substitution from internal combustion vehicles to EVs induced by the policy options.

Estimation of these benefits requires projections, for both the base case and the policy options, of EV and non-EV sales, the composition of the vehicle stock, the availability of destination charging, EV battery range, and unit economic values for destination charging availability, GHG emissions and air pollution.

Base case vehicle projections

Base case vehicle projections are estimated by applying CSIRO projections of EV sales as a share of total sales under the step change scenario to historical sales observations and CIE projections of vehicle sales by type (passenger vehicles, SUVs, and light commercial vehicles). The EV category includes battery electric vehicles only. Plug-in and mild hybrid vehicles are included in the 'other' category. In the analysis that follows, the composition of the 'other' category and changes in that composition over time are accounted for.

6.19 Projected vehicle sales under the base case



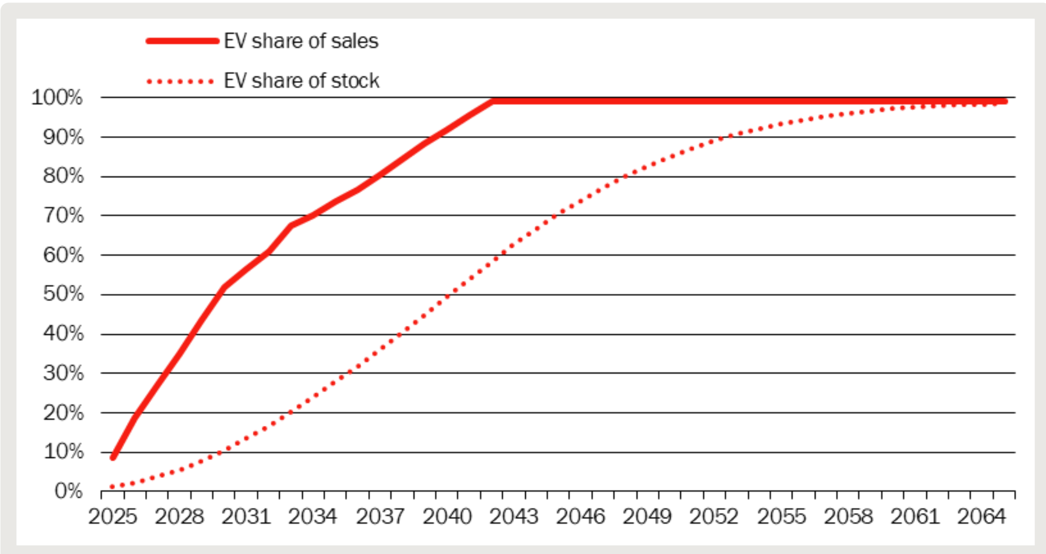
Data source: CSIRO EV projections for EV share of sales, CIE sales projections.

The stock of vehicles was estimated using the following survival curve (Smit et al 2022) where S is the proportion of vehicles surviving to a specific age, A.[133]

$$S = \frac{1}{0.9925 + (1 - 0.9925)e^{0.2840A}}$$

Although EV share of sales reaches 99 per cent by 2042, the EV share of stock is not expected to reach that figure for another 20 years.

6.20 Projected electric vehicle share of stock under the base case



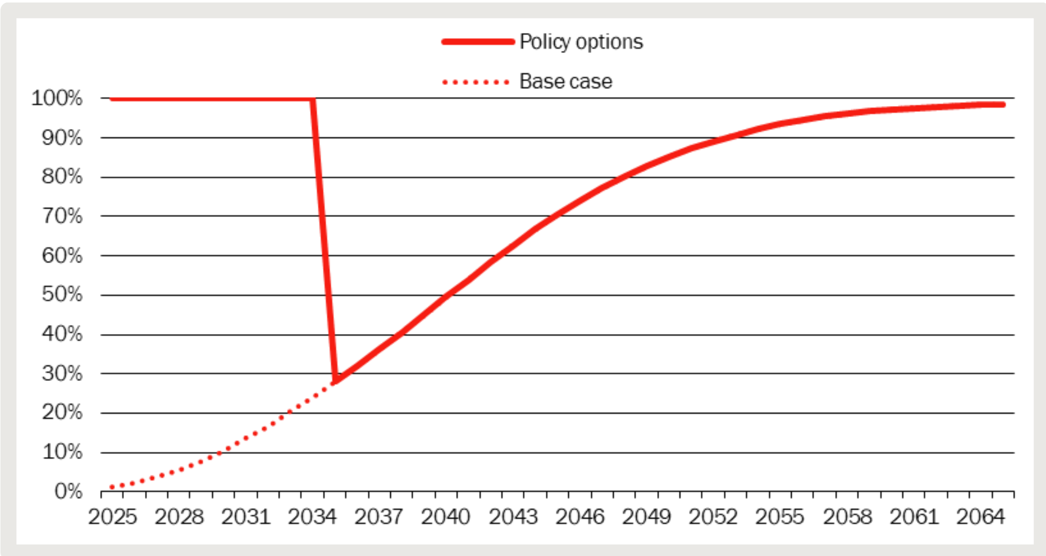
Data source: CSIRO EV projections for EV share of sales, CIE sales projections.

133 Smit, R., Mellios, G. and Papadopoulos, G. (2022). Light-Duty Vehicle CO2 Emission Factors, Energy Intensities and Survival Curves for Australia's Emissions Projections. 30 June.

Vehicle and charging attributes

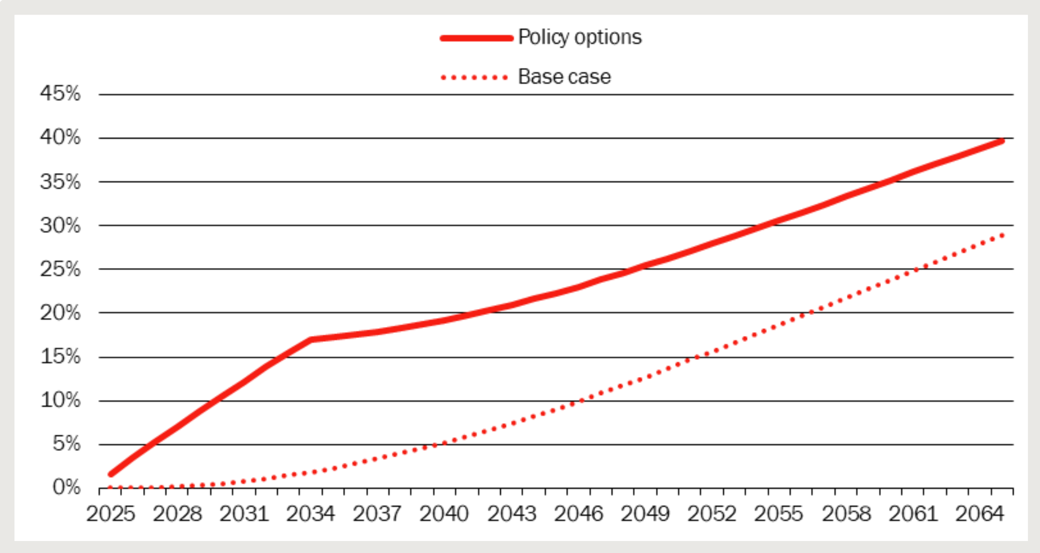
Having established a base case for vehicle demand, we need to estimate how demand would differ under the policy options. Availability of destination charging is the driver of vehicle demand that is changed under the policy options. We consider the value placed by consumers on the 'availability of destination charging' attribute in the CIE's 2019 choice study to be a reasonable measure of the value placed by consumers on improvements in the proportion of commercial buildings offering EV charging. There is little available evidence to inform a forecast of EV charging availability in commercial buildings in the base case. We assume that the proportion of new commercial buildings voluntarily offering EV charging in a given year would be equal to the EV share of the vehicle stock in that year. We consider this to be a reasonably neutral assumption that recognises the incentives for EV uptake to drive installation of EV charging infrastructure and vice versa. Under the policy options, all commercial buildings constructed between 2025 and 2034 would offer EV charging. The proportion of buildings constructed after 2034 with EV charging would be equal to the EV share of the vehicle stock in that year.

6.21 Share of new commercial buildings with electric vehicle charging



Data source: CIE assumptions.

6.22 Share of commercial building stock with electric vehicle charging



Data source: CIE assumptions.

The CIE's 2019 study of the demand for EVs found that the value placed by consumers on this availability depends on the battery range of the EV. We therefore need to make assumptions about battery range and how it will change over the next 60 years. Battery range varies significantly across EV models currently on market. Vehicles with longer range tend to be more expensive. Early adopters of electric vehicles have been wealthier than average and the dominance of vehicles, like Teslas, with range greater than 400 km may diminish as lower-income households begin to substitute to EVs. We therefore assume battery range of 300 km in 2025. This range is similar to that offered by the base models of the increasingly popular BYD Atto 3 and the Hyundai Kona. We assume range will increase by 2 km every year over the projection to 420 km by 2085. We also assume battery range is unaffected by the policy options.

Model of vehicle demand

We constructed utility functions for vehicle consumers for each year under the base case and under the policy options using the main model in the CIE's 2019 choice study. The functions comprised coefficients and levels for the two attributes discussed in the section above — availability of destination charging and battery range — and a constant solved such that the market share predicted by the model for each year in the base case was equal to the CSIRO EV sales projections. These models were used to estimate both the value placed by consumers on increased availability of destination charging and the change in the EV market share under the policy options. Market share is estimated as

$$Pr = \frac{e^{\beta X}}{e^{\beta X} + e^{-1.5}}$$

where βX is the sumproduct of the coefficients and levels from the model below.

6.23 Model of vehicle demand

Variable	Coefficient
Constant	Solved for each year such that market share equals the CSIRO projection, where the assumed utility from an alternative non-EV is -1.5
Availability of destination charging (proportion*100)	0.0086966
Log of battery range (km) * availability of destination charging (proportion*100)	-1.432669

Note: Dependent variable is utility. The price coefficient in the model is -0.0397502. It is included as part of the constant here but used elsewhere to calculate willingness to pay.

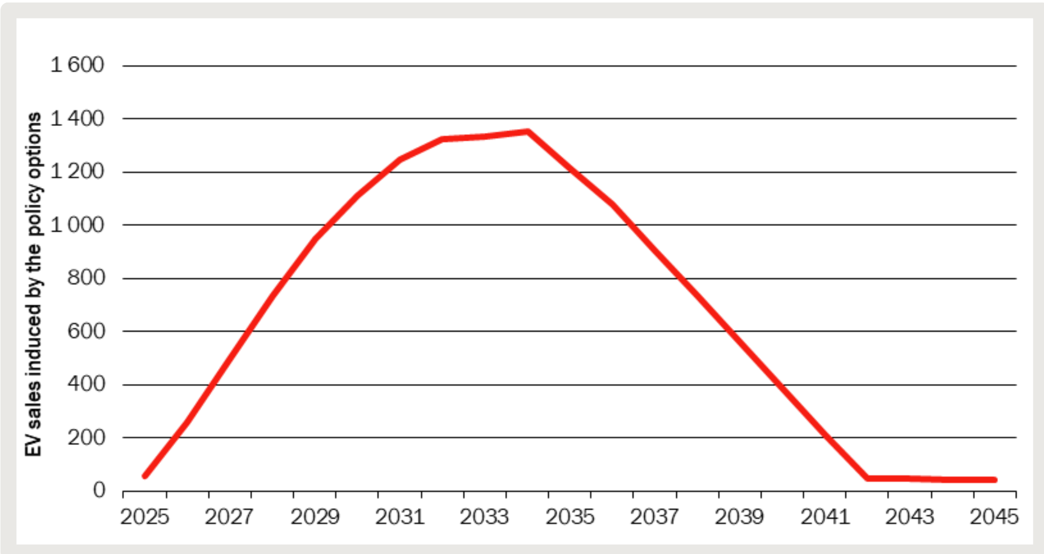
Source: CIE 2019. Demand for electric vehicles. A discrete choice survey. Final report for Australian Automobile Association. 22 January.

This is a model of average preferences to be aggregated over all consumers. Some consumers may place little or no value on destination charging. Others will place a high value on destination charging — for example, consumers who are unable to charge at home. All of these consumers are included in the estimation of this model of average preferences.

Vehicle projections under policy options

The demand for EVs induced by the policy options increases to around 1350 vehicles per year in 2033 before declining due to forecast improvements in battery range.

6.24 Electric vehicle sales induced by the policy options



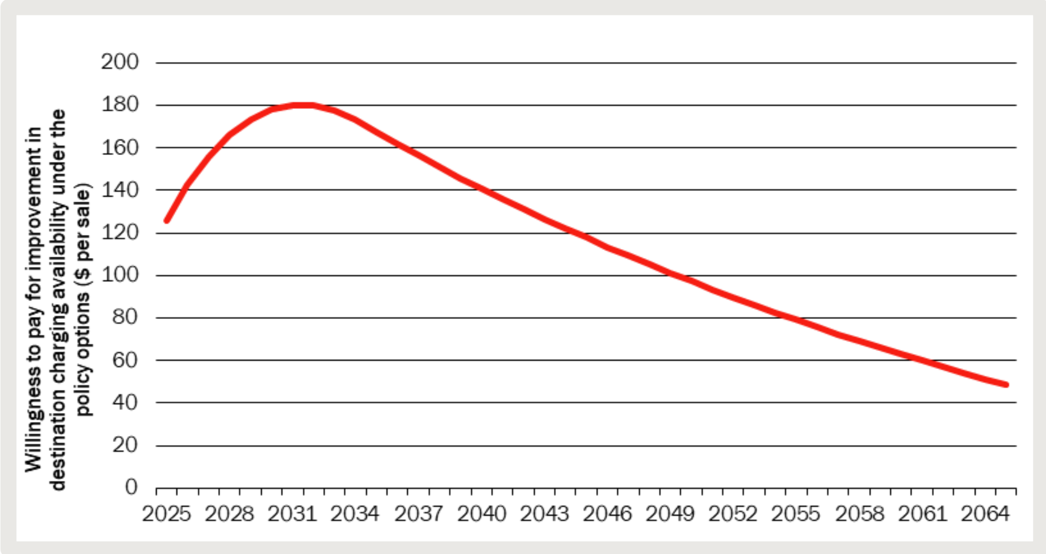
Data source: CIE analysis.

Benefit of improved access to destination charging

The value placed by consumers on improved destination charging is measured as the increase in the amount they would be willing to pay when purchasing the vehicle. We assume the value is based not only on the availability of destination charging at the time the vehicle is purchased, but on the average availability over the subsequent

10 years. Applying the estimated choice model discussed above with these assumptions, the value is estimated at $126 in 2025. It increases with the availability of destination charging over time to $180 in 2032 before gradually declining with forecast improvements in battery range.

6.25 Willingness to pay for improved destination charging availability



Data source: CIE assumptions.

When aggregated across the projected purchases in the base case (and half of the initial stock of EVs on the assumption they are on average halfway through their useful lives) this amounts to around $1.56 billion in present value terms.

As discussed in chapter 4, half of this per-consumer benefit will also accrue to motorists who substitute from a non-EV to an EV as a result of the policy options. This additional benefit totals to $774 000 in present value terms.

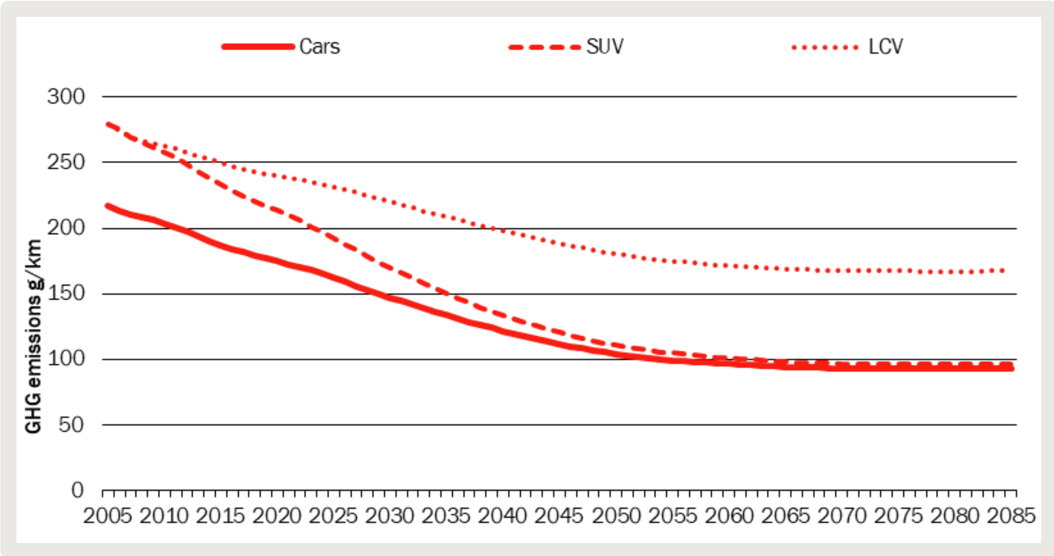
Benefit of climate change mitigation

GHG emissions projections were constructed for both EVs and non-EVs, taking account of the age composition of the stock of vehicles.

For EVs, the projections of emission intensity of electricity from the grid used elsewhere in this report were applied to projections of vehicle kilometres travelled (by vehicle type) and an assumed 16.37 kWh per 100km travelled.

For non-EVs, the age composition of the stock of vehicles was multiplied by the sticker emissions for each respective age (chart 6.26).

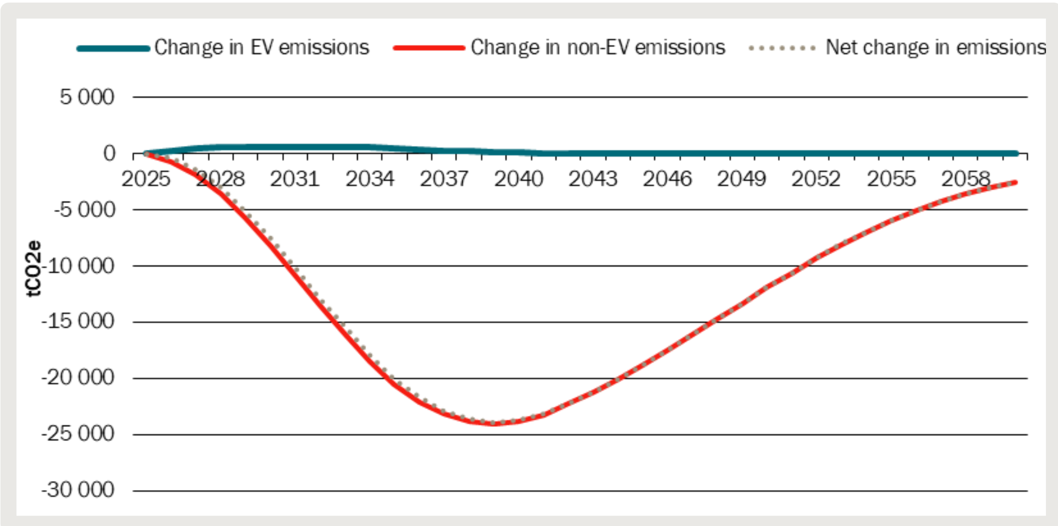
6.26 Emission intensity of new vehicles other than battery electric vehicles



Data source: Sticker emissions.

There is a net reduction in emissions resulting from the substitution to EVs induced by the policy options. When valued at the social cost of carbon, this emission reduction is worth around $84 million in present value terms.

6.27 Impact of policy options on emissions from vehicles



Data source: Sticker emissions.

Benefit of reduced air pollution

There would also be a reduction in air pollution resulting from the substitution to EVs induced by the policy options. Particulate matter and nitrogen oxides from tailpipe emissions can cause adverse health impacts. These emissions are closely correlated with GHG emissions. CIE (2020) calculated,[134] based on work conducted as part of the review of the Fuel Quality Standards Act that the economic value of these impacts is around $60/tCO2e.[135] We apply this figure to the net reduction in emissions discussed above, giving an estimated additional benefit of $12 million in present value terms.

Total benefits from mandatory electric vehicle charging

In total, the estimated benefits of mandatory EV charging in commercial buildings are around $1.7 billion in present value terms (using a discount rate of 5 per cent).

6.28 Total benefits from mandatory electric vehicle charging

Benefit	Estimated benefit $'000s
Improved access to destination charging	1,560,617
Mitigation of climate change	84,059
Mitigation of air pollution	12,105
Total	**1,656,780**

Source: CIE analysis.

Costs

To estimate the number of additional buildings that install EV charging as a result of the proposed changes, we divide projected new construction for each of the relevant building types (in square metres) by the floor space of the buildings used in the cost modelling (table 6.29).

We then use the assumed uptake of EV charging (also shown in the table, which is consistent with the assumption used to estimate the benefits) to estimate the additional number of buildings that install EV charging as a result of the proposed changes to the NCC.

6.29 Additional buildings installing EV charging facilities

Year	Uptake in base case	Hotel[a]	Office building	Warehouse[c]	Laboratory[d]	Factory[e]	Hospital[f]	Aged care facility[g]	Total
	Per cent	No.	No.	No.	No.	No	No	No	No
2025	1.4	943	283	1,791	14	2,503	104	123	5,762
2026	2.4	1,065	320	2,019	16	2,820	117	139	6,496
2027	3.8	1,094	325	2,062	16	2,899	120	142	6,658

134 CIE 2020, *Greenhouse gas emissions projections and economic analysis of emissions reduction in Victoria: Whole of the economy modelling*, prepared for DELWP. September.

135 Marsden Jacobs and Pacific Environment Limited (PEL) 2016, *Review of the Fuel Quality Standards Act 2000*, report prepared for the Australian Government Department of the Environment

Year	Uptake in base case	Hotel[a]	Office building	Warehouse[c]	Laboratory[d]	Factory[e]	Hospital[f]	Aged care facility[g]	Total
	Per cent	No.	No.	No.	No.	No	No	No	No
2028	5.6	1,061	315	2,000	16	2,816	116	138	6,461
2029	7.8	1,051	313	1,985	15	2,786	115	136	6,403
2030	10.5	1,022	305	1,928	15	2,708	112	132	6,222
2031	13.5	1,054	312	1,981	15	2,792	115	136	6,407
2032	16.7	1,018	302	1,914	15	2,694	111	131	6,185
2033	20.3	965	287	1,815	14	2,553	106	125	5,864
2034	24.1	918	272	1,723	13	2,429	100	118	5,573

[a] Floor space for the cost modelling was 1000 m^2. [B] Floor space for the cost modelling was 10 000 m^2. [C] The floor space for the external car park cost modelling was not provided. Average floor space for a warehouse is assumed to be 1360 m^2 (as implied in the Commercial Building Baseline Study) [d] The floor space for the external car park cost modelling was not provided. Average floor space for a laboratory is assumed to be 948 m^2 (as implied in the Commercial Building Baseline Study for a factory). [E] The floor space for the external car park cost modelling was not provided. Average floor space for a factory is assumed to be 948 m^2 (as implied in the Commercial Building Baseline Study) [2]. [F] Floor space for the cost modelling was 2000 m^2. [G] Floor space for the cost modelling was 2000 m^2.

Source: DeltaQ, NCC 2025 Energy Efficiency — Advice on the technical basis, Initial Measures Development: Electrical Services Report, prepared for the Australian Building Codes Board, 26 September 2023, pp. 87-90, Indicative costings for EV charging installations in external car parks, prepared for ABCB, CIE.

The estimated costs of mandatory EV requirements are summarised in table 6.30. These estimates are based on the per building cost estimates (see table 5.12 above) applied to the estimated number of additional buildings that install EV charging (from table 6.29).

6.30 Estimated costs of mandatory EV charging requirements

Year	Estimate lifetime cost
	$ million
2025	422.5
2026	471.5
2027	476.1
2028	453.2
2029	438.5
2030	413.7
2031	411.8
2032	382.7
2033	347.2
2034	314.5
Net present value	**3,396.8**

Note: Table shows estimated costs of providing EV charging facilities over the life (50 years) of all buildings constructed in the relevant year. All net present value calculations use a discount rate of 5 per cent.

Source: CIE estimates

7 Discussion and preliminary conclusions

Discussion of results by component

The CBA results for each element of the proposal (as discussed previously, the options are various combinations of these elements) are discussed below.

Minimum energy efficiency standards

All 3 options under consideration involve more stringent minimum energy efficiency standards. These more stringent minimum energy efficiency standards are estimated to significantly reduce electricity consumption in commercial buildings and therefore avoid:

- generation costs (i.e. wholesale costs)
- network capacity costs
- network usage costs
- retail costs
- associated GHG emissions.

These electricity-related benefits are partly offset by a relatively small increase in gas consumption (and associated GHG emissions).

DeltaQ's modelling suggests that the significant increase in energy efficiency and reduction in GHG emission can be achieved while also reducing capital-related costs for many (but not all) building archetypes.

These results raise the question: why would building owners (and their design teams) not choose a cheaper and more energy efficient choices without the need for regulation?

There are several plausible explanations, including the following:

- Inefficiencies in the building process (including regulatory processes) mean there is limited opportunities to optimise costs and performance from a whole-of-building perspective. Changes to the code that increase the efficiency of the building envelope allow cost savings through reducing the plant size.
- The proposed changes to the code encourage right-sizing of plant by specifying efficiency at design loading. The modelling assumes this will encourage a 5 per cent reduction in plant size, while still allowing extensive over-sizing to reflect standard practice.
- The proposed changes to the code address existing inefficiencies, including:

  - excessive insulation requirements in some buildings that actually reduces building performance;
  - the current requirement for internal walls to be insulated, which adds to cost while having little to no impact on performance.

However, the proposed changes to the NCC will also restrict design choices in several ways, including the following:

- The windows on some buildings will need to be tinted (i.e. have lower visual light transmittance) to achieve compliance with the proposed requirements — although this will still allow an adequate level of daylighting (daylighting requirements are not specified in the NCC), this will be less than what is current practice.
- The maximum WWR that will be achievable without external shading will be reduced from 70 per cent (under NCC 2022) to 58 per cent — although this will not affect most building archetypes (as the WWR for most buildings is lower than this threshold), this will have some impact, particularly on large office buildings where extensive glazing is relatively common.
  - Note that DeltaQ's modelling assumes the same WWR under the base case and under all stringencies and does not include the cost of shading. This is because the archetypes are intended to reflect a 'representative' building based on the average WWR within the building class. Previous work estimated the average WWR for an office tower is around the maximum threshold achievable without shading (around 58 per cent).
  - This means that the proposed requirements will not affect the 'average' office tower and therefore these effects are not reflected in the modelling.
  - However, around half of office towers will have higher WWRs than average and would be affected by this restriction and would need to either install external shading (which can be expensive) or reduce the WWR.
- As the minimum standards have been tightened across all building elements there will be fewer opportunities to make trade-offs across elements (including through the use of Performance Solutions) to achieve particular design outcomes.

These restrictions on design choice will impose costs that have not been measured, which could include the following:

- Loss of aesthetic or amenity value — where design compromises have been made, there may be a loss of aesthetic or amenity value. Although these values are subjective, in principle design compromises that change either the external appearance or the internal aesthetics for building users are likely to involve a net cost to the community.
  - There are no identifiable market failures that would lead building owners and designers to make design choices that are systematically sub-optimal from a communitywide perspective in relation to building aesthetics/amenity (although there are some market and behavioural failures in relation to energy efficiency choices — see appendix A).
  - In the absence of identifiable market failures, a standard assumption in economic analysis is that market participants will make design choices that

achieve the optimal combination of cost and building aesthetic/amenity value, particularly where these values are reflected in the market value of the building and/or rents.

  - To the extent that these aesthetic/amenity values are reflected in the market value of these buildings and/or rents, these benefits could in-principle be measured. However, there is no publicly available data that would allow these values to be estimated.
- Additional financial costs — where building owners and their design teams choose to achieve their preferred design outcome through the use of external shading, they will incur an additional financial cost.
  - Although the costs of external shading have not been explicitly modelled, we understand that external shading is costly and likely to outweigh the benefits of greater energy efficiency.
  - The choice to incur the financial costs associated external shading would indicate a strong preference for the relevant design features (i.e. extensive glazing and/or glazing with high visual light transmittance).

Although these unmeasured costs could potentially be significant, it is unlikely that they would affect enough building archetypes to outweigh the measured benefits at the aggregate level.

Mandatory rooftop solar

Installation of rooftop solar on commercial buildings is a requirement under Option 2 and Option 3. This requirement is also estimated to deliver significant net benefits.

Unlike Stringency Level 1, mandatory rooftop solar on commercial buildings is likely to impose additional costs. However, DeltaQ's modelling indicates that the additional costs are likely to be significantly outweighed by the benefits — including reduced consumption of electricity from the grid, increased export of electricity to the grid and the associated GHG savings.

The net benefits from installing rooftop solar on commercial buildings is reflected in the relatively high voluntary uptake of rooftop solar under current arrangements (where rooftop solar is not mandatory), based on available evidence.[136] This voluntary uptake is incorporated into the base case, which significantly reduces the net benefits attributable to the proposed changes to the NCC.

That said, our modelling may over-estimate the net benefits from mandatory rooftop solar for the following reasons:

- the net benefits from installing rooftop solar may mean greater voluntary uptake of rooftop solar may increase in the future under the base case, meaning that fewer benefits can be attributed to the regulatory change;

136 See: Strategy.Policy.Research. *Research report: use of renewable energy to trade-off energy efficiency requirements in Section J of the National Construction Code*, Prepared for the Department of Industry, Science, Energy and Resources, 20 January 2022, p. 4.

- there may be some buildings where installation of rooftop solar is not viable due to shading, alternative uses for the roof or other factors. This has not been taken into account in the modelling (i.e. the modelling assumes that all commercial buildings will install rooftop solar). In most of these cases an exemption will apply.

These factors would reduce both the benefits and costs attributable to the proposed regulatory change proportionately. So although the modelling may overstate the net benefits to some extent, the costs would not outweigh the benefits as a result of these factors.

On the other hand, our modelling does not take into account the amount of rooftop solar in the base case (only considering whether they have solar or not). It is possible that the proposed requirements would increase the amount of rooftop solar on buildings where there is voluntary uptake.

In contrast to the increase in the mandatory energy efficiency requirements, there are less likely to be direct (hidden) aesthetic/amenity impacts associated with mandatory rooftop solar, due in part to the exemptions available.

That said, there may be some indirect impacts as a result of mandating rooftop solar. In particular, installation of rooftop solar is one way that building owners/designers make trade-offs against other elements to achieve preferred design outcomes. Previous work for DISER found that 8 per cent of the buildings surveyed had installed rooftop solar as a trade-off against other elements (around 20 per cent of all buildings that had installed rooftop solar).[137]

If rooftop solar becomes mandatory that trade-off will no longer be available, meaning that building owners/designers may need to make design compromises elsewhere.

Provisions to achieve net zero buildings at least cost

The provisions to achieve net zero buildings apply to Option 3 only. These provisions have a relatively modest impact (compared to the other elements) at the aggregate level. This is partly because these provisions apply to only 3 building archetypes (the large hotel, the large office building and the large hospital ward) as these are the only dual-fuel archetypes that have been modelled.

The net impact of these requirements depends on whether dual fuel buildings will convert to fully electric in the future.

- Where dual fuel buildings are not required to convert to fully electric buildings in the future, these provisions will result in a net cost.
- Where dual fuel buildings are required to convert to fully electric in the future, these provisions will result in a net benefit.

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137 Strategy.Policy.Research. *Research report: use of renewable energy to trade-off energy efficiency requirements in Section J of the National Construction Code*, Prepared for the Department of Industry, Science, Energy and Resources, 20 January 2022, p. 8.

This future scenario is currently unknown. The **expected** outcome is the probability-weighted average of these scenarios. Based on the modelling results, the provisions to achieve net zero buildings at least cost 'breaks even' (implying the costs are equal to the benefits), where the probability that dual-fuel buildings are required to convert to fully electric in the future is around **28 per cent** (where all other assumptions are held constant, including: 50 per cent of buildings would choose the dual fuel offset; and 50 per cent would choose to 'electrify now'; and all dual fuel buildings would be required to convert to fully electric 20 years after construction). This implies the following.

- If the probability that dual fuel buildings will be required to convert to fully electric is considered greater than 28 per cent, the provisions to achieve net zero at least cost would deliver a net benefit.
- If the probability that dual fuel buildings will be required to convert to fully electric is considered less than 28 per cent, the provisions to achieve net zero at least cost would deliver a net cost.

Another relevant consideration is that the dual fuel offset option (this compliance option is estimated to be cheaper than the 'electrify now' option may impose some additional costs that have not been modelled. In particular, this option will require most building archetypes to install ground-mounted solar due to limitations on roof space.

This may not be possible in many circumstances and where possible, this could affect the aesthetic value.

Mandatory EV charging facilities

All of the proposed options require mandatory EV charging facilities to be installed in commercial buildings.

This requirement is estimated to impose a net cost on the community. This result largely reflects the relatively low value that consumers appear to place on destination charging (based on previous CIE estimates from a stated preference survey). This value is also likely to decline further as battery range improves.

As consumers place a relatively low value on charging facilities at the destination, our estimates suggest that greater provision of charging facilities in commercial building car parks is unlikely to induce significant additional uptake of EVs.

The relatively low value that consumers place on charging facilities at the destination is likely to reflect the expectation that most charging will be done at home. The preferences of consumers (or potential consumers) that are unable to install charging facilities at home may be higher than average; however, the results of the stated preference survey suggest that there may be relatively few EV drivers (or potential drivers) in this category. Although an industry estimate suggests that up to 20 per cent of homes may be in this category, it is possible that these households are less likely to be EV drivers.

These results suggest that for the Decision RIS, the mandatory EV charging requirements should be de-coupled from the other requirements and presented as a separate discrete option. This will allow this requirement to be considered as a separate policy choice.

Preliminary conclusions

All three options under consideration are estimated to deliver significant net benefits compared with current NCC 2022 requirements as a baseline.

Option 2 upgraded energy efficiency requirements and mandatory rooftop solar delivers the highest net benefits.

Option 3 also achieves great benefits that are slightly lower than Option 2, noting as shown in the sensitivity analysis, Option 3 can deliver better results in some scenarios.

Based on the CBA results, mandatory EV charging facilities delivers net costs. This element might need to be decoupled from the other requirements and considered separately.

A Review of direct evidence on market failures and behavioural anomalies

This appendix provides more detailed discussion on direct evidence on market failures and behavioural anomalies presented in chapter 2 (especially the summary table 2.2).

Direct evidence of market failures in energy pricing

Direct evidence on market failures in energy pricing is summarised below. In summary:

- There is a significant market failure as the external costs associated with GHG emissions are not reflected in energy prices. On average, the external costs associated with electricity consumption are currently estimated at around 23.5 c/kWh.
- Consistent with the Australian Energy Regulator (AER) Guidelines, the costs associated with peak demand are largely reflected in energy prices, albeit imperfectly.

Greenhouse gas emissions

In the current policy environment, the lack of an economy wide carbon price is the clearest market failure in relation to energy consumption. There are various approaches to valuing GHG emissions. Using the internationally recognised SCC approach, the external cost of carbon emissions associated with electricity consumption is currently (2023) estimated at around 21.7 c/kWh based on:

- a social cost of carbon of around $313 per tonne of CO_2-e in 2023-dollar terms—this is based on the following:
  - The United State Environment Protection Agency's (US EPA's) most recent (2022) estimate of the SCC of US$190 per tonne of CO_2-e (expressed in 2020 US dollar terms using the 2.0 per cent discount rate) is used as the starting point.[138]

[138] US Environment Protection Agency 2022, *Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review"*, EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances, September 2022, p. 3.

  - The US EPA's US dollar estimate is then converted to Australian dollar terms using an exchange rate of US$0.74.6 per Australian dollar (based on a 10-year average to February 2023).
  - Reflecting the upward trend in the US EPA's estimates of the SCC over time, this 2020 estimate is inflated by 5.8 per cent (1.9 per cent per year) to obtain a 2023 estimate.
  - This is then inflated to 2023-dollar terms using the Australian national CPI (consumer prices increased by 16 per cent between 2020 and 2023).
- an average carbon intensity of electricity of around 0.71 tonnes of CO_2-e per MWh across Australia in 2023.

While the carbon intensity of electricity generation is expected to decline over time, USEPA estimates suggest that the SCC will increase, based on rising populations and economic growth.

GHG emissions are being valued significantly higher in the RIS than in the 2018 RIS (~5 c/KWh), reflecting higher estimates of the SCC in the USEPA's most recent publication and a lower discount rate used in relation to the SCC estimates. However, this is partly offset by more optimistic projections of the extent to which the electricity grid will decarbonise.

To put this estimate into context, if the SCC were internalised into the wholesale electricity price, it would be more than double (around 114 per cent higher, based on the average National Electricity Market (NEM) wholesale price in 2022 of 19.1 c/KWh). This implies that the externalities associated with electricity consumption are currently higher than the generation costs.

Unpriced negative externalities associated with energy consumption, would normally mean that energy users do not take these costs into account in their decisions on whether to invest in energy efficiency. However, many companies — including some commercial building owners — are committed to reducing GHG emissions as part of ESG commitments in line with Environmental, Social and Governance (ESG) commitments. In particular:[139]

- Research by the Climateworks Centre reported that 84 of the 187 ASX companies assessed (45 per cent) have a scope 1 and 2 net zero target. However, only 16 of the 177 ASX companies assessed (9 per cent) where scope 3 emissions are deemed applicable have set a net zero target for scope 3 emissions in line with a 1.5C pathway.
- Other research has reported that by March 2023, 121 ASX 200 entities had set public commitments to reduce emissions to net zero by 2050 or earlier. The ASX200 is ramping up efforts on climate reporting, with 75 per cent of the companies committing to or reporting against the Taskforce for Climate-related Financial Disclosures framework (66 per cent in 2022 reporting year). There are 9 companies of ASX 200 adopted Say on Climate initiative to disclose annual

139 Climateworks Centre, Net Zero Momentum Tracker, 1.50C climate goal: How does the ASX200 stack up in 2022?, Highlights Report, December 2022, p. 6.

emissions and plans of action or decarbonisation strategies which are open to annual non-binding votes by shareholders.[140]

This indicates that some companies are already valuing GHG abatement even though it is not internalised into energy prices. However, not all of these targets are being actioned, and not all commercial building owners and tenants have made such commitments. As such, there is a clear role for government intervention.

Externalities associated with peak demand

As electricity network capacity is driven by peak demand, reducing peaks through energy efficiency can potentially defer or remove the need for additional investment to expand network capacity.

However, to a significant extent, the cost of supply during peak periods is reflected in energy prices. As a natural monopoly, network charges are regulated by the AER. Under the AER's pricing principles, network tariffs must reflect the long run marginal cost (LRMC) of supply.

For network services, the LRMC is a forward-looking concept reflecting both the operating costs associated with an additional unit supplied, and any network expansion costs. As such, the LRMC reflects the avoidable network costs from reducing energy consumption.

Reflecting these pricing principles, electricity tariffs typically include:

- a capacity charge — this is a daily charge based on the maximum usage during specified peak periods over a specified period
- usage charges which could include different peak and off-peak rates to reflect differences in the cost of supply during peak and non-peak periods.

To a large extent, network-related costs are therefore reflected in electricity tariffs. That said, capacity charges may imperfectly reflect network-related costs. Previous work has shown that tariff structures vary significantly across different networks; it is unclear whether this reflects actual cost differences across different network areas or different approaches taken by network operators.

Other market failures and behavioural anomalies

Although there is limited direct evidence, it is plausible that the following behavioural/organisational failures prevent privately cost-effective energy efficiency opportunities (i.e. where energy bill savings outweigh the associated capital costs) from being adopted.

140 Australian Council of Superannuation Investors, *Promises, pathways and performance: Climate change disclosure in the ASX200*, August 2023, pp. 5–12, https://acsi.org.au/research-reports/promises-pathways-and-performance-climate-change-disclosure-in-the-asx200/, accessed 1 November 2023.

- There are some split incentives that could contribute to sub-optimal outcomes, including where:
  - different parts of an organisation are responsible for capital costs and operating costs (energy bills)
  - there are different incentives across different parties in the building process.
- Behavioural anomalies, such as bounded rationality and heuristic decision making (such as building to code, rather than seeking the optimal mix of capital and ongoing energy costs); and inattention to non-salient energy costs are plausible explanations for the energy efficiency paradox across all building types.

Information failures

In the context of new commercial buildings, an 'information failure' would arise if the party that makes decisions on the energy efficiency of the building design and the associated services installed (such as building owners or developers, architects and engineers acting on their behalf) does not have access to sufficient information to make fully informed decisions.

However, information failures are not a compelling explanation for any failure of industry to adopt privately cost-effective energy efficiency opportunities as relevant information is available.

- General information on the potential benefits of improving energy efficiency in commercial buildings is freely available through a range of sources, including government sources and energy efficiency advocacy groups.
- More project-specific information is commercially available from specialist consultants and energy efficiency modellers (information costs are not a market failure). Performance Solutions, which involve energy efficiency modelling, are frequently used to comply with Section J of the NCC (although some stakeholders reported that the DTS pathway continues to be used for some buildings). Nevertheless, this suggests that energy efficiency modelling is an established part of the building design and construction process.

The extent to which this information is accessed and acted upon is a separate issue addressed below.

Information asymmetries

Another form of information failure is an 'information asymmetry'. This occurs where one party in a transaction has more information than another. In the context of energy efficiency in commercial buildings, an information asymmetry would arise where a building (or part of a building) is sold or rented and the seller/landlord has information on the associated energy bills, while the buyer/tenant does not. Under these circumstances the buyer/tenant may not be in a position to make informed decisions and higher levels of energy efficiency may not be reflected in leases or sale prices.

However, there is little evidence to suggest a significant information asymmetry problem in relation to energy bills under typical leasing arrangements. The responsibility for paying energy bills can vary depending on the type of lease.

- Where some or all of the energy bills are directly passed onto tenants (referred to as a net lease), expected 'outgoings' are typically provided to tenants at the time of choosing office or retail space. This allows tenants to choose the tenancy that offers the preferred mix between lease rates and outgoings (as well as a range of other characteristics).
- Where energy costs are included in the lease, (referred to as a 'gross lease'), the amount paid by tenants is fully transparent.

In addition, there are several other existing mechanisms to address the potential for these information asymmetries:

- Energy efficiency rating tools allow building owners/operators to obtain a rating for their building from an accredited assessor using an established methodology. These arrangements mean that buyers/tenants can have confidence in the energy efficiency rating provided by the seller/landlord. Existing energy efficiency rating tools include:
  - The National Australian Built Environment Rating System (NABERS) operated by the NSW Government on behalf of Federal, State and Territory Governments. Compared with 2018 (when the previous commercial energy efficiency RIS was completed) there are now NABERS Energy rating tools available for a broader range of buildings. NABERS Energy tools are available for:
    - Office buildings and tenancies
    - Shopping centres
    - Apartment buildings
    - Hospitals (public)
    - Hotels
    - Data centres
    - Residential aged care
    - Retirement living
    - Warehouses and cold stores.[141]
  - The Green Star rating system operated by the GBCA. Green Star is a holistic sustainability rating system.
- In addition, the CBD program requires that sellers and lessors of office space of 1,000 m^2 or more to obtain a Building Energy Efficiency Certificate — which includes the building's NABERS Energy for Offices star rating and a tenancy

141 NABERS website, https://www.nabers.gov.au/ratings/our-ratings/nabers-energy, accessed 16 October 2023.

lighting assessment of the relevant area of the building — before the building goes on the market for sale, lease or sublease.[142]

Stakeholders also reported that investor demand for green buildings provides a significant incentive to achieve high levels of energy efficiency at the premium end of the office market. Investor demand for green buildings is driven by the recognition of the commercial benefits of better energy efficiency (such as lower energy bills, higher rents and lower vacancy rates) as well as corporate social responsibility requirements of large investors. Some stakeholders also reported that NABERS or Green Star ratings are often used as a market proxy for overall building quality.

Previous reviews found that the CBD program had been successful in encouraging energy efficiency improvements, particularly in the least efficient buildings.[143] While the focus of the CBD program is on existing buildings, it nevertheless suggests that existing mechanisms go some way to addressing the information asymmetry problem. However, as noted above, mandatory disclosure of the NABERS energy efficiency rating is applied only to a subset of commercial buildings. As a result, the problem of information failure should be addressed for those commercial buildings not being covered by the CBD.

Evidence of energy bill savings being capitalised into rents and building values would be an indicator that tenants and buyers have sufficient information to make informed decisions. There is some Australian evidence to suggest that more energy efficient buildings tend to attract a premium in both rents and sale prices. However, this mostly applies to prime office buildings.

- A recent (2023) CBRE report compared average rents of 130 office buildings in major Australian cities (Brisbane, Melbourne, Perth and Sydney) based on their NABERS rating.[144]
  - On average, rentals were around 8 per cent higher in 6-star buildings (compared with the average across the same city)
  - An average discount of 6 per cent (relative to the average in the same city) was observed in buildings with a rating of 4 stars (at the lower end of the sample).
- Knight Frank used a hedonic price model to estimate the impact of NABERS rating on the sale price of prime office buildings in Melbourne and Sydney. They found that:[145]

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142 Commercial Building Disclosure website, http://cbd.gov.au/overview-of-the-program/what-is-cbd, accessed 17 October 2017.

143 Acil Allen Consulting 2015, *Commercial Building Disclosure: Program Review*, Report to the Department of Industry and Science, March 2015, pp. 42-46.

144 CBRE 2023, The Green Building Premium: Does It Exist, March 2023, https://www.cbre.com.au/insights/viewpoints/asia-pacific-viewpoint-the-green-building-premium-does-it-exist, accessed 1 November 2023.

145 V Ormond 2021, *Green building value: do green-rated buildings add a premium to sales price?*, Knight Frank, 29 September 2021, https://www.knightfrank.com/research/article/2021-09-29-green-building-value-do-greenrated-buildings-add-a-premium-to-sales-price, accessed 1 November 2023.

 – Buildings with a NABERS rating of 5+ achieve an average 17.9 per cent premium on sales price compared to equivalent unrated buildings.
 – Buildings with a lower NABERS rating achieve an average 8.3 per cent premium.
- A more comprehensive (albeit older) Australian study for the Australian Property Institute and Property Funds Association also found evidence of energy bill savings associated with higher levels of energy efficiency being capitalised into rents and prices (as well as lower vacancy rates). The study compared rents and prices of 206 NABERS-rated office buildings and 160 office buildings that did not have a NABERS rating in Sydney and Canberra. This study focused mostly (over 97 per cent) on office buildings with an area exceeding 2,000 m^2. A key feature of this study is that it controlled for differences in building characteristics to ensure that any identified 'green premium' is not a result of green buildings being newer.[146] The study found:
 – Evidence of a green premium in values for buildings with higher NABERS ratings:
  … a 5-star NABERS energy rating delivering a 9 per cent 'green premium' in value (relative to unrated buildings), and
  … a 3 to 4.5-star NABERS rating delivering a 2-3 per cent green premium in value.
 – These green premiums were most evident in the Canberra office market and the Sydney suburban office market (North Sydney, Parramatta, Chatswood, St Leonards, South Sydney, Norwest, Macquarie Park, Rhodes and Homebush Bay).
 – Green premiums were also evident in reduced vacancy rates and reduced outgoings.[147]

Note that these studies have used the NABERS rating (based on GHG emissions) as the measure of energy efficiency, rather than energy consumption *per se* (there is not necessarily a close correlation between NABERS rating and energy consumption). It may be that the observed premiums reflect environmental objectives, rather than direct financial considerations alone.

In this regard, it should be noted that the CBD Program currently covers offices with an area at or above 1,000 m^2. There may be some information asymmetries (in relation to the NABERS rating) for other commercial buildings.

146 Newell, Graeme, John MacFarlane and Nils Kok 2011, *Building Better Returns: A Study of the Financial Performance of Green Office Buildings in Australia*, Research by the University of Western Sydney and the University of Maastricht Netherlands in conjunction with Jones Lang LaSalle and CBRE for The Australian Property Institute and Property Funds Association, p. 22.

147 ibid, p. 41.

Split incentives

A subset of information failures discussed above is the issue of split incentives. Split incentives occur when the party making the decision on whether to invest in energy efficiency is not responsible for energy bills.

Landlord-tenant problem¤

The most commonly cited split incentive in relation to commercial buildings is the landlord-tenant problem. This problem potentially applies to leased buildings where:

- the building owner (the landlord) bears the cost of any investment in energy efficiency (including the building façade and central services); and
- energy bills are passed onto tenants (although this is not always the case).

The landlord-tenant problem is potentially most relevant to office and retail buildings where leasing is common. These are the largest commercial users of energy, together accounting for over 40 per cent of the total energy consumed by commercial buildings.

It is less relevant to other types of commercial buildings, such as educational facilities, health-care facilities and hotels, where the building owner and operator are more likely to be the same entity and responsible for both decisions on whether to invest in energy efficiency, and energy bills. However, there may be organisational inefficiencies that limit the appropriate consideration of the longer-term operating cost implications at various levels of capital expenditure decisions for these types of commercial buildings.

In general, a landlord-tenant split incentive problem is more likely to be a significant barrier to the uptake of privately cost-effective energy efficiency opportunities where an information asymmetry is present. Where energy bill savings are understood by tenants, they are likely to be willing to pay higher rents in more energy efficient buildings in exchange for lower energy bills. In these circumstances, the benefits of better energy efficiency are shared between the building owner/manager and the tenant. The capacity to achieve higher rents would also be reflected in the value of the building.

That said, a split incentive may apply within a contract period. The financial incentive for a landlord to improve energy efficiency is muted by having to pass savings on to tenants for part of the tenant base.

As discussed above, disclosure of outgoings (as well as the availability of benchmarking tools such as NABERS) means that information asymmetries and therefore the landlord-tenant problem are not likely to be a significant barrier to greater energy efficiency in commercial buildings in Australia.

Builder and end-user split incentive problem

Another source of split incentives reported by stakeholders in Australia is between a building contractor and its owner/occupier. As discussed in the International Energy

Agency (IEA)'s 2007 report, *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency*, a building contractor makes many energy-related decisions, including the efficiency of the heating system and of the windows, and the building's resistance to air infiltration. However, given these energy efficient alternatives usually increase the cost of construction, 'the building contractor has incentives to avoid these measures, especially if the measures are invisible to prospective buyers'.[148] That is, the developer is naturally trying to build for the lowest cost possible, and would incur the capital cost of energy efficiency investments, while the end user is not identified and may potentially not pay the full cost of those investments.

This applies to all building types and particularly to those developments that are completed speculatively, or where there is a fixed-price build and energy efficiency measures may be reduced to increase the builder's margin. Due to the complexity of observing the compliance to design after building, it may be difficult for the owner to observe the difference between the planned and actual level of energy efficiency during the construction phase.

Other types of split incentives

Another type of split incentive could occur within large organisations, where separate parts of the organisation are responsible for capital budgets and paying energy bills. This is effectively an organisational failure, rather than a market failure. This type of split incentive was previously identified during stakeholder consultations as a key barrier to improved energy efficiency in government buildings, as a result of government budgeting arrangements.

Bounded rationality and heuristic decision-making

In addition to the market failures discussed above, some studies cite behavioural anomalies/failures as a reason for under-investment in improved energy efficiency. Behavioural anomalies cited in the literature include bounded rationality and heuristic decision-making.

Energy efficiency choices in commercial buildings may involve complex trade-offs with factors, such as design preferences as well as cost. In the face of this complexity, some owners/developers may make sub-optimal decisions due to cognitive limitations and/or rely on heuristics (mental short cuts).

In an assessment of the evidence on the causes of the energy efficiency gap, Gerarden *et. Al.* (2015) noted that cognitive limitations could conceivably contribute to the energy efficiency gap by preventing individuals (or possibly firms) from properly

148 International Energy Agency (IEA), *Mind the Gap - Quantifying Principal-Agent Problems in Energy Efficiency*, IEA, 2007, https://www.ctc-n.org/sites/www.ctc-n.org/files/resources/mind_the_gap.pdf, accessed 3 November 2023.

balancing the present value of benefits against costs when investing in energy-using capital goods.[149]

Gerarden *et. Al*. (2015) note that many empirical studies are consistent with this explanation. However, it is difficult to disentangle the role of heuristics and bounded rationality from competing explanations because consumers' decision-making processes cannot be directly observed.[150]

Given these challenges, it is difficult to find direct evidence that bounded rationality and heuristic decision-making contributes to the energy efficiency paradox in relation to commercial buildings.

That said, there is qualitative evidence from stakeholders that entrenched practices in the construction industry — a form of heuristic decision making — is a key barrier to greater uptake of energy efficiency in commercial buildings in Australia. Energy efficiency can sometimes be overlooked or ignored as a lower order imperative to life safety.

In particular, current processes for the design and construction of commercial buildings (including the regulatory processes) reportedly precludes optimisation of energy efficiency from a whole building perspective.

- A key early step in the design and construction process is obtaining planning approval. Planning approval is mainly focused on the building envelope.
- This means that in many cases the façade is designed and submitted to the planning authority for planning approval, without any involvement of the energy efficiency consultant or the mechanical engineer that design the HVAC system.
- Once planning permission has been received, the energy efficiency consultant and mechanical engineer will design the HVAC system for the approved façade. Any significant changes to the façade may require a variation to the planning approval, which can result in delays and add to costs.
- This process means that energy efficiency may not be optimised from a whole-of-building perspective. Many buildings are therefore built to comply with the minimum energy efficiency standards specified in the NCC (i.e. 'building to code'), rather than seeking to optimise between capital and operating costs.

Another way that heuristic decision-making can lead to sub-optimal outcomes is where mechanical engineers are heavily focused on performance and therefore build in significant redundancy when making decisions on the sizing of HVAC equipment.

Inattention and non-salience of energy costs

Some studies have sought to explain the energy efficiency paradox as a result of the inattention of energy users and/or the salience of energy costs. As energy costs are

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149 Gerarden, Todd D., Richard G. Newell, and Robert N. Stavins 2015, "Assessing the Energy Efficiency Gap" Cambridge, Mass.: Harvard Environmental Economics Program, January 2015, p. 28.

150 ibid, p. 28.

relatively small component of total costs for many businesses, little attention is paid to them, leading to under-investment in energy efficiency.

Gerarden *et. Al*. (2015) found some evidence that consumer inattention to non-salient costs affect decisions.[151] However, most of the research cited relates to consumers rather than businesses.

While there is little direct evidence that inattention to energy costs leads to under-investment in energy efficiency, it is nonetheless a plausible explanation (particularly for small businesses).

Alternative explanations

As discussed above, the failure of industry (and government) to adopt energy efficiency opportunities that modelling shows is privately cost-effective is often explained through the market and behavioural failures outlined above. However, an alternative view in the international literature is that the perceived energy efficiency gap may be much smaller than it appears because the modelling may not always be accurately reflecting the true costs and benefits of energy efficiency measures.

Some of the potential modelling issues identified in the energy efficiency literature include the following:

- Over-estimation of energy savings — in many CBAs, energy saving estimates are based on engineering estimates, particularly in the case of *ex-ante* CBAs where actual energy saving cannot be observed. There is some evidence that engineering estimates can significantly overstate the energy savings achieved from improved energy efficiency. Gerarden et. Al. (2015) noted that studies that over-estimate energy savings have persisted, despite improvements in *ex-ante* engineering-economic methods over time.[152] A review of more recent evidence suggests that the performance gap remains an ongoing issue, although difficult to quantify (see Appendix C for details).
- Under-estimation of energy efficiency improvements under the base case scenario — the Productivity Commission has previously noted that policy makers may overstate the potential for regulation to deliver cost-effective improvements in energy efficiency because their assumed business-as-usual improvements in energy efficiency are too pessimistic and fail to anticipate the responsiveness of consumers to future reductions in the prices of energy-efficient products.[153]
- Heterogeneity across buildings — investments in energy efficiency that appear privately cost effective for the average consumer (or developer in the case of

[151] ibid, pp. 24-26.

[152] For further details see: Gerarden, T.D., Newell, R.G. and Stavins, R.N. 2015, *Assessing the Energy Efficiency Gap*, Duke University Energy Initiative and Harvard Environmental Economics Program, January 2015, pp. 17-19.

[153] Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Productivity Commission Inquiry Report No. 36, 31 August 2005, p. 236.

commercial buildings) may not be cost-effective for some consumers due to different preferences, actual usage and/or the cost of capital.[154]

- Risk and uncertainty — investment in energy efficiency involves some degree of risk or uncertainty, including uncertainty in relation to energy savings and future energy prices.[155] Various studies have noted that risk is a common explanation for firms rejecting the recommendations from energy audits.[156] As noted by the Productivity Commission, if the degree of risk and uncertainty facing producers and consumers is not adequately recognised, estimates of the potential for taking up energy efficiency related investments will be overstated.[157]
- Omitted and under-estimated costs — some studies argue that energy efficiency modelling can often omit certain costs and therefore overstate the net impact of investing in energy efficiency. As noted by the Productivity Commission, well-informed purchasers of non-residential buildings may want to forgo the energy savings from a building standard because the standard causes more highly valued characteristics to be lost.[158]

If the apparent energy efficiency gap is due to these modelling issues, regulation could potentially impose a net cost on building owners (energy efficiency investment costs are bigger than the actual energy bill savings). The public benefits of reduced GHG emissions would therefore need to outweigh these private costs for energy efficiency regulations to deliver a net social benefit (the combined benefits of net changes in energy bills plus reduction in GHG emissions are larger than the energy efficiency investment costs).

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154 Gillingham, K. and Palmer, K. 2014, "Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence", *Review of Environmental Economics and Policy*, **8**(1), p. 21.

155 Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Productivity Commission Inquiry Report No. 36, 31 August 2005, p. 62.

156 Gillingham, K. and Palmer, K. 2014, "Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence", *Review of Environmental Economics and Policy*, volume 8, issue 1, p. 21.

157 Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Productivity Commission Inquiry Report No. 36, 31 August 2005, p. 62.

158 ibid, p. 236.

B Avoided energy-related costs

This appendix details the estimation of energy prices to be used in the impact analysis and the CBA in the main body of the report.

Approach to measuring avoided energy costs

A key issue in CBAs of energy efficiency regulation is the approach to measuring the benefits of the energy saved. Conceptually, CBAs of energy efficiency proposals are seeking to measure avoided resource costs (i.e. the avoided resources such as labour inputs, fuels, generation and transmission infrastructure that would have been used to supply electricity and gas).

It is important to note that this benefit is in addition to the benefits of a reduction in GHG emissions associated with energy savings. The benefits of emissions reduction may be valued using a SCC or market or shadow price of carbon. The RIS uses an SCC, as discussed above.

There have been various approaches to valuing energy savings used in RISs and CBAs (box B.1). A standard approach in partial equilibrium analysis (used in most CBAs) is to value avoided resource costs using the market price of goods and services.

- In competitive markets, the market price reflects the opportunity cost of the resources used in the production of the good or service at the margin.
- From a practical perspective, it is also more convenient to observe the price of a good or service than to estimate the opportunity cost of the inputs used in production. For example, it is easier to measure the market price of a loaf of bread than to measure the value of the labour, avoided capital costs associated with the bakery, the costs associated with growing the wheat and milling the flour used in its production.

B.1 Avoided energy costs

As has been discussed elsewhere, there are fundamentally two ways that reduced resource costs to supply electricity and gas have been measured in CBAs:

- The retail price approach — under this approach, energy savings are valued using the retail price. The retail price captures all the components of supply, such as generation, transmission, distribution and retailer costs
- The 'capacity and energy approach' — in general, this approach involves assessing to what extent avoided energy consumption reduces the need for investment in energy generation and energy network capacity.

In the context of avoided electricity costs, applying this general principle would lead to the **retail price approach**. However, there would be a case for adjustment if some components of the retail price are:

- fixed (for example charged based on the days of connection) rather than relating to the energy consumption; or
- likely included in other benefits of energy saving (for example some costs related to climate change policies) to avoid double counting.

We therefore use the retail price to value the energy savings from more stringent minimum energy efficiency standards for commercial buildings, with some adjustment for fixed charges and avoiding double counting (discussed in more details below).

To ensure manageability of the analysis, we use average energy prices for each jurisdiction or climate zone (where data available), incorporating relevant weights, in the central case CBA. Furthermore, considering the wide range of tariffs as detailed further in the following discussions and substantial uncertainties around the energy price projections in the future, we will consider different energy prices during the sensitivity analysis.

Components of electricity prices

According to the Australian Competition and Consumer Commission (ACCC), the retail price of electricity includes the following components:[159]

- generation costs (also referred to as energy costs);
- network costs
- environmental costs
- retail and other costs, and
- retail margins.

159 ACCC 2022, *Inquiry into the National Electricity Market*, November 2022 Report, 23 November 2022, p.115.

We will further discuss these components below, delving into their inclusion/exclusion and estimation with greater detail.

Generation costs

The wholesale market is the most competitive segment of the electricity supply chain and therefore market prices are a reasonable indicator of the marginal cost of generation.

For electricity market outside of the NEM, the balancing market price compiled by AEMO provide the basis for the wholesale electricity prices in WA.[160] Historical daily trading data maintained by Northern Territory Electricity System and Market Operator (NTESMO) provide the basis for the wholesale electricity prices in NT.[161]

We construct a price series as a component for use in the analysis drawing on these data sources.

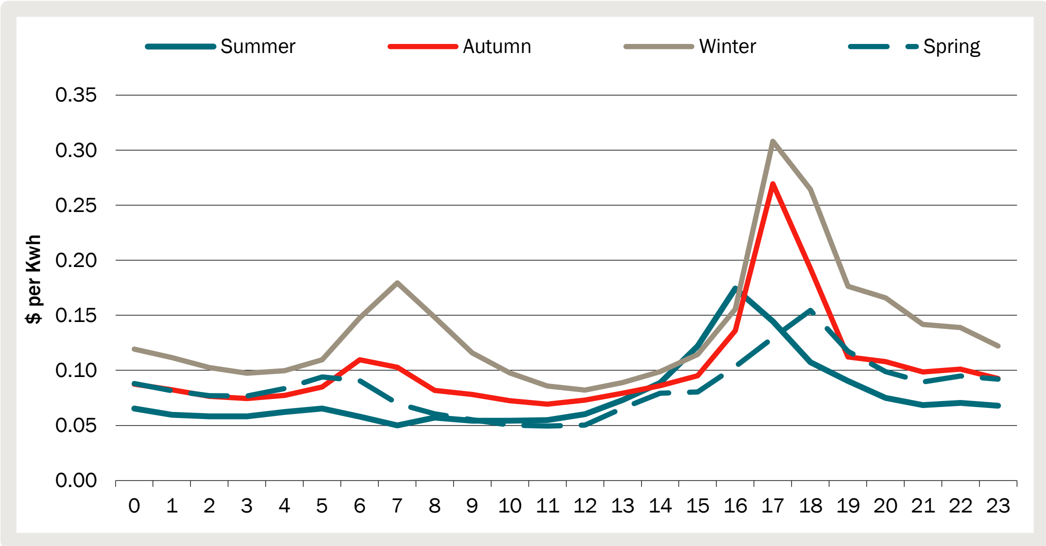
To estimate the time of use prices, we use historical market data from the national electricity market in 2022. The wholesale prices were reported in a 5-miniute interval. We aggregated them into hourly rates (8760 hourly intervals across the year) using relevant volume weights.

Wholesale prices exhibit substantial daily fluctuations as well as seasonal variation. These fluctuations also tend vary across states. Charts B.2 to B.9 shows the wholesale price fluctuations across an average day in each season for each state and territory.

160 AEMO, 'Market Data - Western Australia', in *data.wa.aemo.com.au*, 2023, https://data.wa.aemo.com.au/#balancing-summary , accessed 3 November 2023.

161 Northern Territory Electricity System and Market Operator (NTESMO), 'Historical daily trading data', in *NTESMO*, 2022, https://ntesmo.com.au/data/daily-trading/historical-daily-trading-data, accessed 3 November 2023.

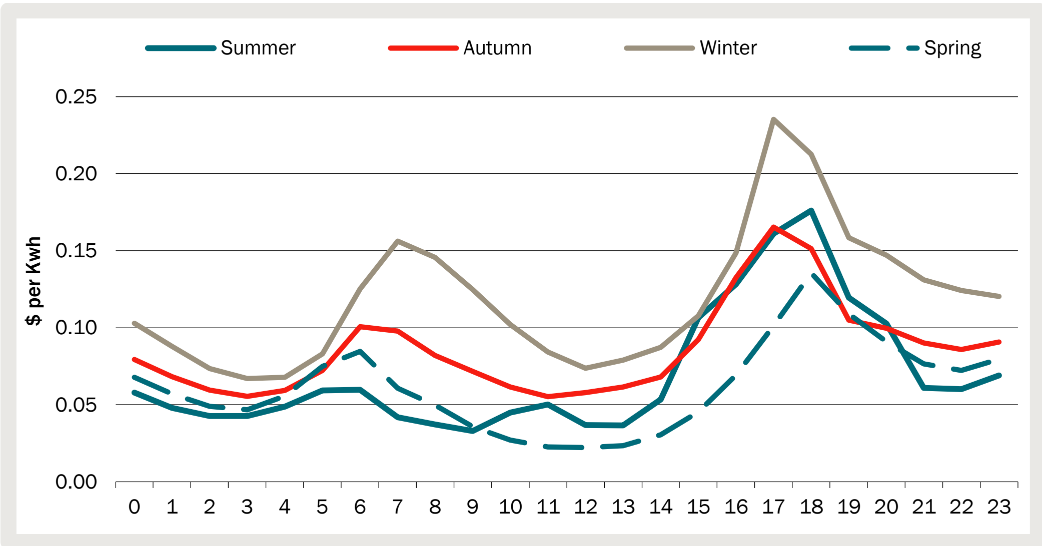
B.2 Average wholesale electricity prices 2019-2021 — NSW



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'NEM data dashboard', 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem.

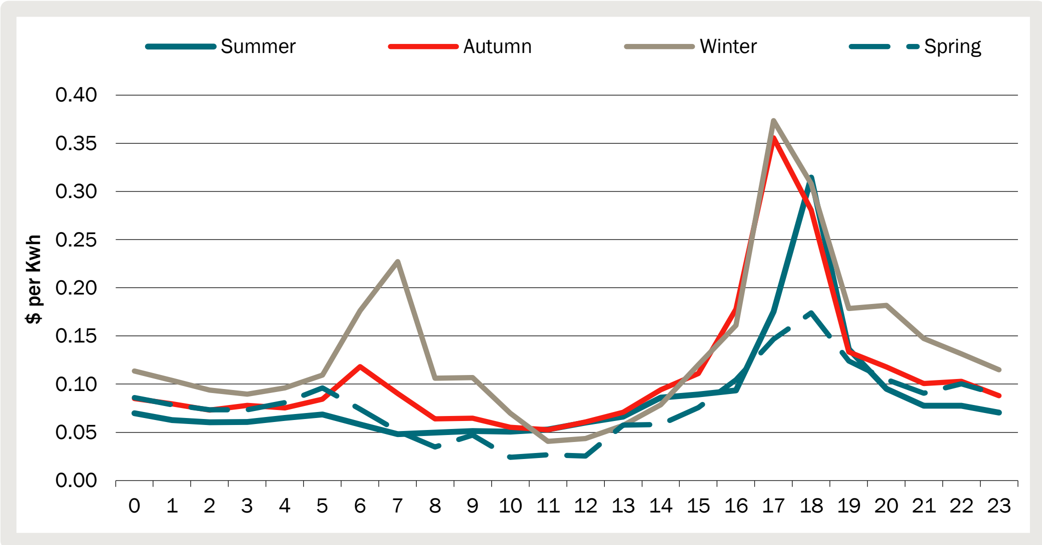
B.3 Average wholesale electricity prices 2019-2021 — Victoria



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'NEM data dashboard', 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem.

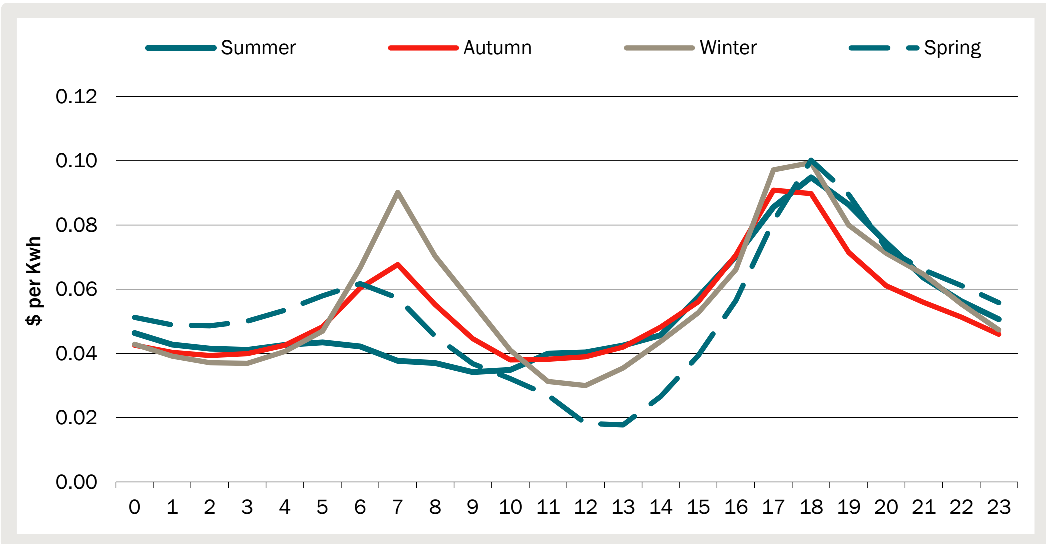
B.4 Average wholesale electricity prices 2019-2021 — Queensland



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'NEM data dashboard', 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem.

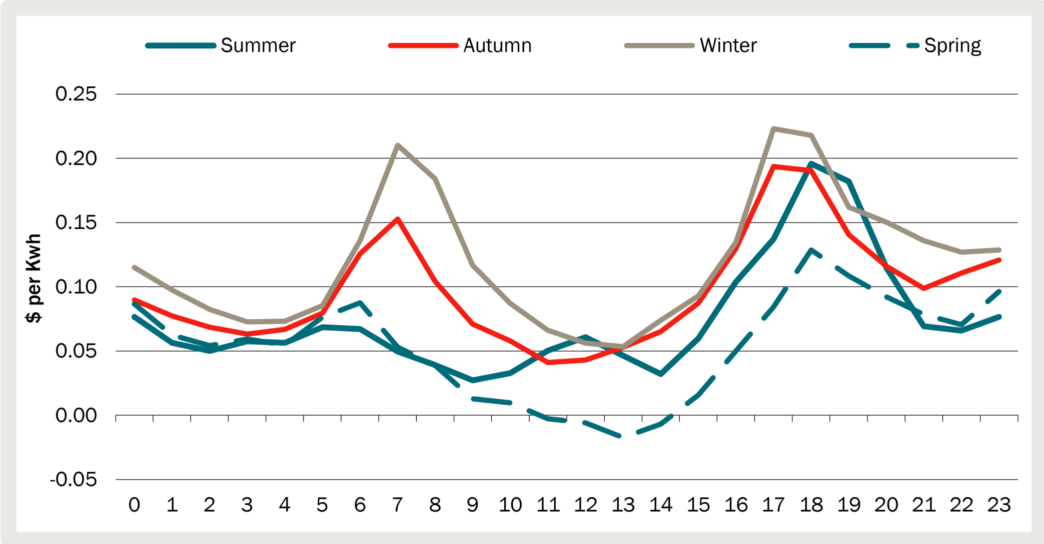
B.5 Average wholesale electricity prices 2019-2021 — Western Australia



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'Market Data - Western Australia', in data.wa.aemo.com.au, 2023, https://data.wa.aemo.com.au/#balancing-summary.

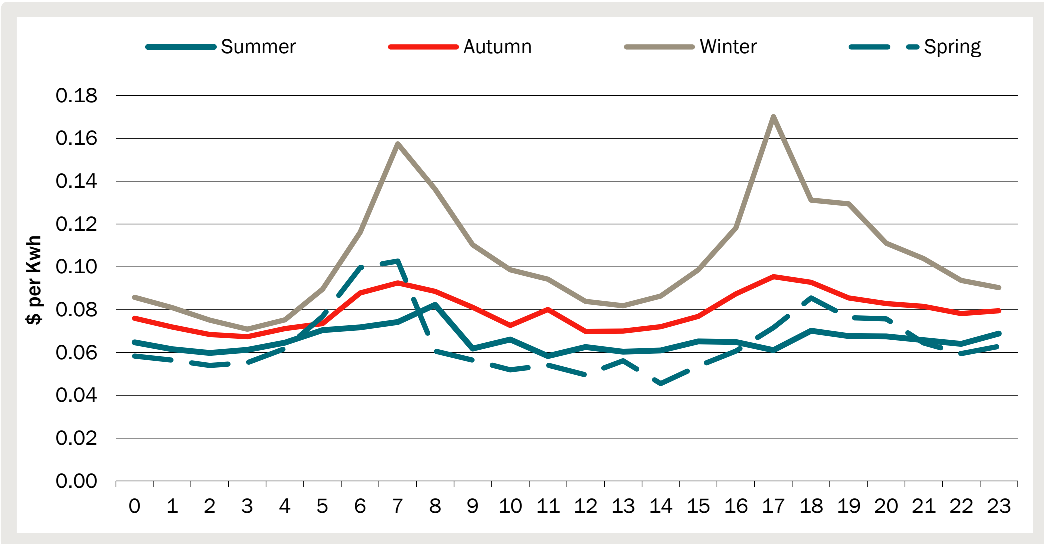
B.6 Average wholesale electricity prices 2019-2021 — South Australia



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'NEM data dashboard', 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem.

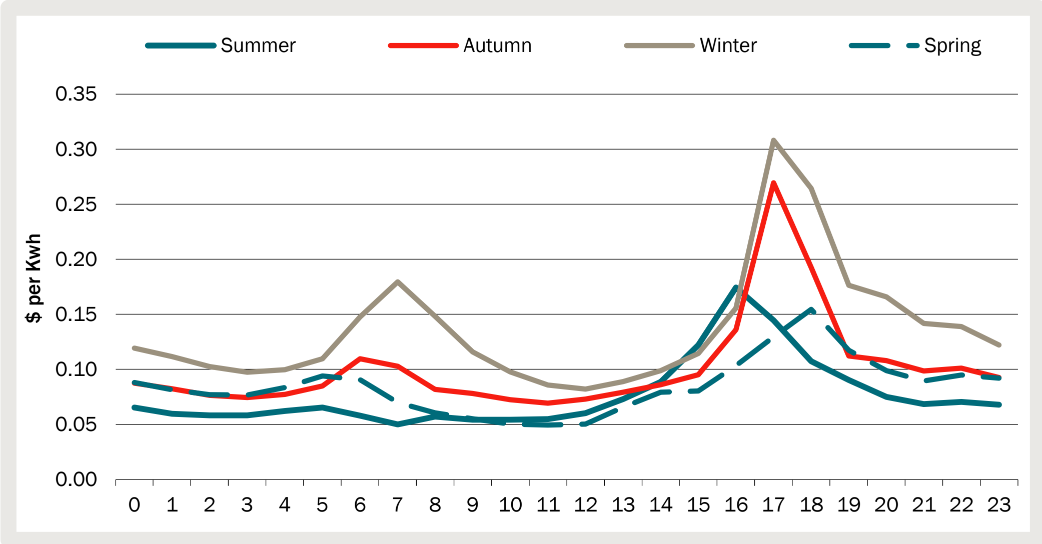
B.7 Average wholesale electricity prices 2019-2021 — Tasmania



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'NEM data dashboard', 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem.

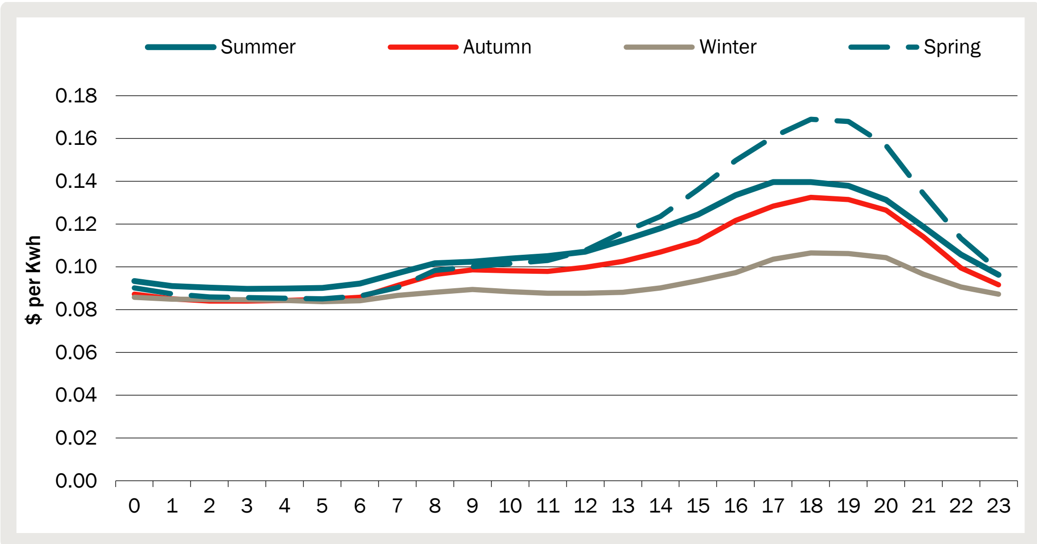
B.8 Average wholesale electricity prices 2019-2021 — ACT



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: AEMO, 'NEM data dashboard', 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem.

B.9 Average wholesale electricity prices 2019-2021 — Northern Territory



Note: Summer covers December to February. Autumn covers March to May. Winter covers June to August. Spring covers September to November.

Data source: Northern Territory Electricity System and Market Operator (NTESMO) 2022, 'Historical daily trading data', https://ntesmo.com.au/data/daily-trading/historical-daily-trading-data

Network costs

To determine network charges, we reviewed the price offerings lodged by each provider with AER,[162] and, in Western Australia, the pricing lodged by Western Power with the Economic Regulation Authority of Western Australia (ERAWA).[163] A thorough examination of pricing from a total of 15 providers or distributors has been conducted.

Network charges are complex and have wide ranges, as shown by the analysis by DeltaQ.[164]

Distributors typically maintain multiple tariff codes to accommodate various user categories (residential, business, etc.) and voltage requirements. For example, Ausgrid has 29 tariff codes in its proposed pricing for 2023-24.[165]

For each tariff code, the total network charges, or network use of system (NUOS), generally have three components:

- distribution use of system (DUOS), which are the charges related to relate to the conveyance of electricity from the transmission network, or generators embedded in the distribution network, to customers, covering the cost of installing and maintaining local electricity distribution networks;
- transmission use of system (TUOS), which are the charges related to the cost of shared network services to convey electricity from sources of generation connected to the transmission network to customers; and
- jurisdictional scheme amounts (JSA), which are the costs of government policies mandated into network tariffs.

The JSAs are mostly, if not all, costs related to government environmental and renewable energy policies. Examples for 2023-24 include:

- the Climate Change Fund, NSW Electricity Infrastructure Roadmap contribution determination and the Roadmap exemption in NSW
- Solar Bonus Scheme in the form of feed-in tariff and Energy Industry Levy in QLD

162 Australian Energy Regulator (AER), 'Pricing proposals and tariffs', in *Networks and pipelines*, 2023, https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/pricing-proposals-tariffs, accessed 26 May 2023.

163 Western Power, 'Network access prices', in *Regulation*, 2023, https://www.westernpower.com.au/about/regulation/network-access-prices/,accessed 26 May 2023.

164 DeltaQ, *Electricity Network Tariff Review*, report for Department of Industry, Science, Energy and Resources (DISER), 30 March 2022.

165 Ausgrid 2023, *Ausgrid – Annual pricing 2023-24*, 31 March 2023, https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/pricing-proposals-tariffs/ausgrid-annual-pricing-2023%E2%80%9324, accessed 26 October 2023.

- PV feed-in tariff and AGL Designated Services Scheme in SA [166]
- Premium PV feed-in tariff and Energy Safe Victoria electricity levies in VIC,[167] and
- Utilities Network Facilities Tax, and Feed-in Tariff (small, medium and large scale) in the ACT.[168]

JSAs are recovered from customers of each distributor through consumption charges and thus included as part of NUOS. According to the 2023-24 pricing proposal of Power and Water Corporation (NT), Western Power (WA) and TasNetworks (Tasmania), there appears no jurisdiction scheme that they administrated and thus no JSA applicable to their customers. Distributors in other jurisdictions cover contributions to state-level schemes through JSA charges ranging from $0.77/kWh to $13.13/kWh.

For DUOS and TUOS, distributors commonly introduce a combination of fixed supply charges, usage or consumption charges, and demand or capacity charges. The fixed supply charges are assessed based on the duration of connection and remain unaffected by variations in energy consumption. Consequently, these fixed charges are not considered in the network charges when evaluating changes in energy consumption resulting from proposed modifications to energy efficiency requirements in the NCC.

Energy usage or consumption is billed based on kilowatt-hours (kWh) or megawatt-hour (MWh) while the demand or capacity charges are determined by kilovolt-amperes (kVA) or kilowatts (kW) per day. kW represents the ‘actual’ power received by a user, indicating the amount of power converted into useful, working output. On the other hand, kVA is the measure of ‘apparent’ power, representing the total power being used in the system.

Most distributors implement time of use pricing for energy consumption and demand/capacity charges to align with the fluctuating energy demand during peak hours, weekdays, weekends and public holidays, through setting up charging windows with different consumption charges in forms of peak, shoulder (if applicable), and off-peak windows defined for a period of time in a day.

Additionally, some distributors incorporate seasonal time of use pricing to account for seasonal variation in energy demand throughout the year. For instance, Ausgrid’s business customers encounter peak window charges between 2pm and 8pm on

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166 Australian Energy Regulator, *AER approves SA Power Networks jurisdictional scheme application*, 23 January 2023, https://www.aer.gov.au/communication/aer-approves-sa-power-networks-jurisdictional-scheme-application.

167 Powercor, *Pricing Proposal 2023-24*, May 2023, p.4, https://media.powercor.com.au/wp-content/uploads/2023/05/17152236/Powercor_2023-2024_Pricing_Proposal.pdf.

168 ARGYLE Consulting and ENDGAME Economics 2022, *Network tariffs for the distributed energy future*, final paper for the Australian Energy Regulator, June 2022, p.11, https://www.aer.gov.au/system/files/Argyle%20Consulting%20and%20Endgame%20Economics%20-%20Battery%20tariffs%20-%20Network%20tariffs%20for%20the%20DER%20future_0.pdf, accessed 25 October 2023.

working weekdays during both summer mouths (from 1 November to 31 March) and winter months (from 1 June to 31 August).[169]

Network capacity costs

Avoided network capacity costs are estimated based on the network capacity charges that apply in each state and territory (table B.10). Although there is some variation in the way network capacity charges are applied, they are typically based on the peak usage during an hourly interval (within a designated peak period) in the relevant billing period (usually monthly).

B.10 Network capacity charges

Month	NSW	VIC	QLD	WA	SA	TAS	ACT	NT
	$/kVa/day	$/kVa/day	$/kVa/day	$/kVa/day	$/kVa/day	$/kVa/day	$/kVa/day	$/kVa/day
January	0.38	0.44	0.38	0.07	0.40	0.60	0.34	0.46
February	0.38	0.44	0.38	0.07	0.40	0.60	0.34	0.46
March	0.38	0.44	0.38	0.07	0.40	0.60	0.34	0.46
April	0.28	0.00	0.38	0.07	0.00	0.60	0.34	0.46
May	0.28	0.00	0.38	0.07	0.00	0.60	0.34	0.46
June	0.38	0.00	0.38	0.07	0.00	0.60	0.34	0.46
July	0.38	0.00	0.38	0.07	0.00	0.60	0.34	0.46
August	0.38	0.00	0.38	0.07	0.00	0.60	0.34	0.46
September	0.28	0.00	0.38	0.07	0.00	0.60	0.34	0.46
October	0.28	0.00	0.38	0.07	0.00	0.60	0.34	0.46
November	0.38	0.00	0.38	0.07	0.40	0.60	0.34	0.46
December	0.38	0.44	0.38	0.07	0.40	0.60	0.34	0.46

Source: CIE based on review of network operators' pricing proposals in each state or territory.

To estimate avoided network capacity costs we use the following approach:

- We first estimate the change in peak hourly usage (in designated peak periods where relevant) each calendar month (in kWh) based on DeltaQ modelling.
- We then convert the peak usage to kVa using a power factor of 0.9.[170]
- We then multiply the change in peak consumption by the capacity charge (in kVa per day).
- Finally, we multiply by the number of days in the relevant month and then sum across months to get an annual estimate of the avoided network capacity costs.

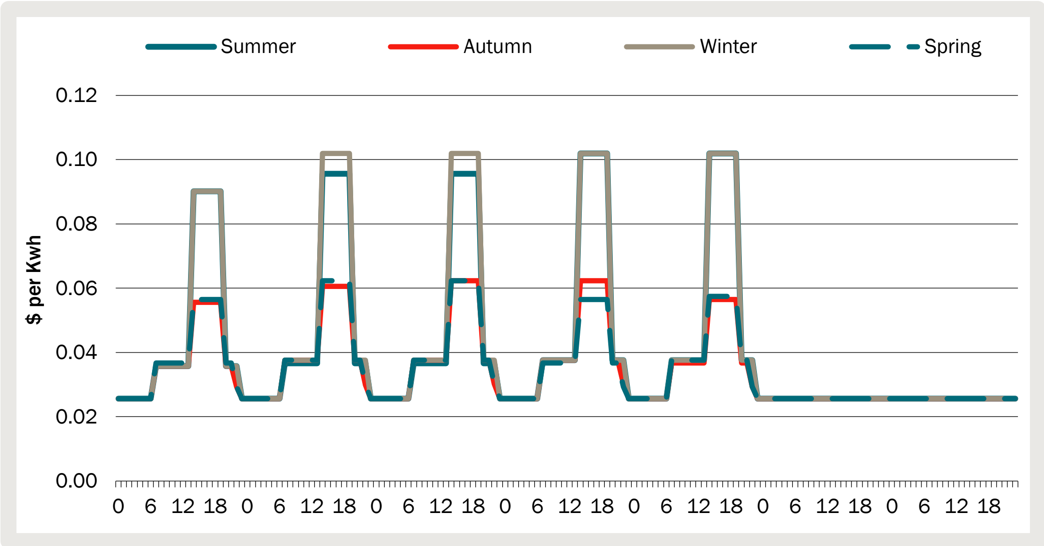
[169] Ausgrid, 'Time of use pricing - Ausgrid', 2022, https://www.ausgrid.com.au/Your-energy-use/Meters/Time-of-use-pricing, accessed 26 May 2023.

[170] The power factor (PF) is a value between 0 and 1, indicating how efficiently the power is used in the system – kVA = PF x kW. The value of 0.8 appears a typical approximate value, for example, see https://www.vedantu.com/physics/relation-between-kva-and-kw.

Network usage costs

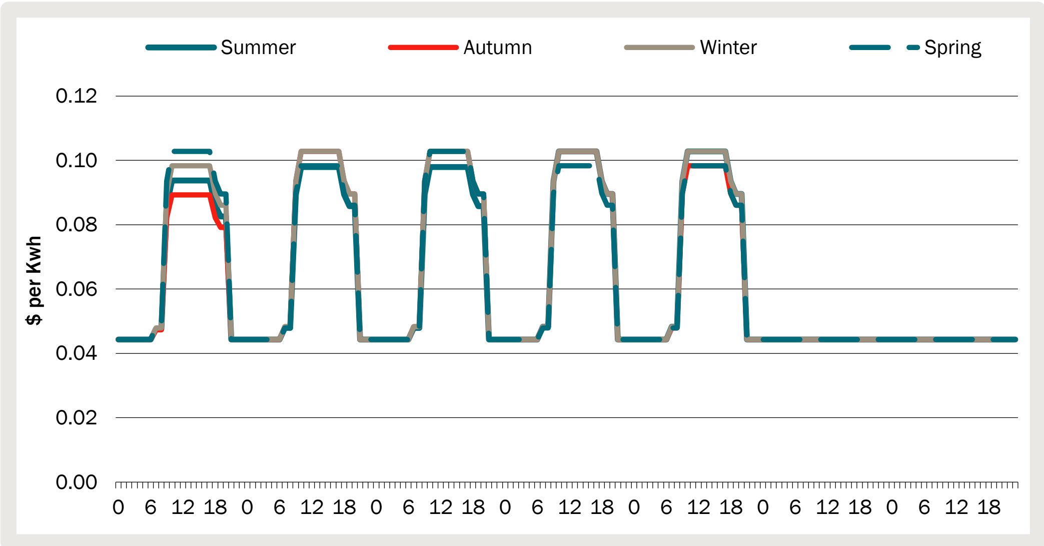
Avoided network usage costs are estimated based on network usage charges. Network usage charges vary by time of use and in some cases, by time of year. In particular, network usage charges vary by time of year in NSW (see chart B.11) and to a lesser extent Victoria (see chart B.12).

B.11 Hourly network usage charges across an average week — NSW



Data source: CIE based on review of network operators' pricing proposals in each state or territory.

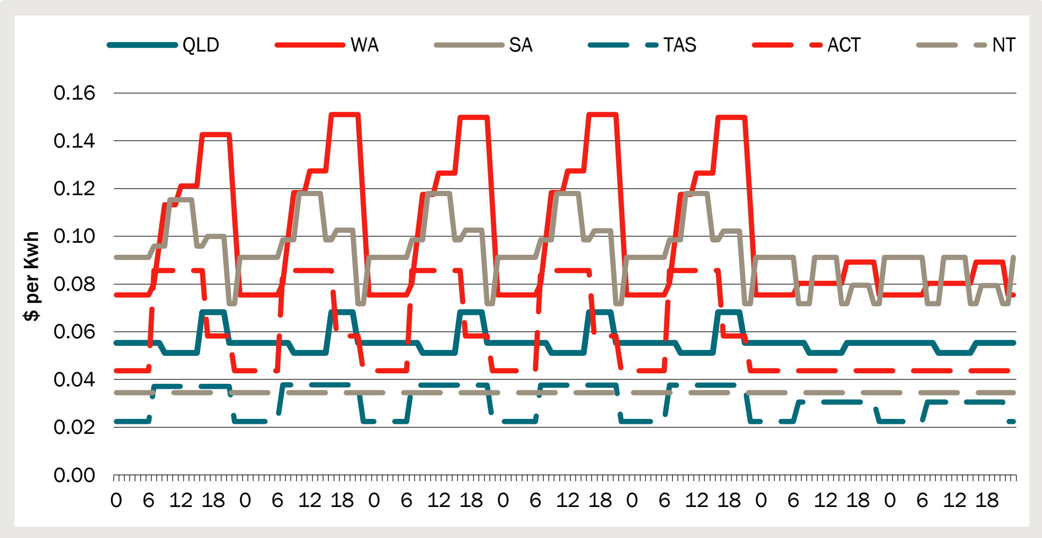
B.12 Hourly network usage charges across an average week — Victoria



Data source: CIE based on review of network operators' pricing proposals in each state or territory.

Network usage charges tend to vary less by time of year in other states and territories, but in most cases vary by time of day (see chart B.13).

B.13 Hourly network charges across an average week — other states and territories



Data source: CIE based on review of network operators' pricing proposals in each state or territory.

Environmental scheme costs

Another cost component usually included in retail prices is the cost associated with environmental schemes. There are two key environmental schemes:

- the Large-scale Renewable Energy Target (LRET — see box B.14); and
- the Small-scale Renewable Energy Scheme (SRES).

These schemes effectively provide a subsidy to relevant renewable energy generators, with the cost of the subsidy allocated across energy users based on energy usage.

B.14 The Large-scale Renewable Energy Target

The LRET incentivises the development of renewable energy power stations through a Renewable Energy Certificate Market for the creation and sale of certificates called large-scale generation certificates (LGCs).

- LRET-accredited power stations can create LGCs for electricity generated from that power station's renewable energy source.
- These LGCs can be sold to 'liable entities' (mainly electricity retailers).
- Retailers are required to surrender a specified number of LGCs to the Clean Energy Regulator (CER) every year.

The number of LGCs that retailers must surrender is set by the renewable power percentage (RPP). The RPP is effectively set at a level that aims to achieve a specified target. This target was incrementally increased over the period from 2001 to 2020, but has now been fixed at 33 TWh until 2030.

These environmental schemes are policy instruments designed to reduce emissions. They are about to achieve an absolute target while specified in terms of proportion of energy sales. Energy savings may not change the total charges – less consumption is offset by higher unit charges.

In terms of measuring the benefits of reducing energy consumption (through proposed changes to the NCC), we therefore exclude the costs associated with environmental schemes.

Retail costs and margin

The retailer costs comprise the retailer's operating costs and margin. Retailer's operating costs (call centres, revenue and billing collection, customer acquisition and retention, and IT systems) are usually driven by the number of customers, rather than energy consumption. As such, these costs would not change as energy usage decreases through the additional energy efficiency requirements in the NCC 2025.

On the other hand, the retail margin is generally assumed to be applied as a percentage of the other costs. If energy costs decrease, then the operating margin applied to those costs would also decrease. As a result, the retail margin should be included as an avoided cost when evaluating the energy savings.

In its final determination on default market offer (DMO) prices for 2022-23, the AER has set a transition of the retail allowance for small business customers to 15 per cent for small business customers because it 'is at the lower end of previous small business allowances and enables the DMO prices to maintain approximately the same aggregate level of allowance across the DMO regions and customers.'[171] In its final determination on DMO prices for 2023-24, AER has adhered to this 15 per cent small business customer retail allowance target while adjusting down the allowance in jurisdictions where the existing allowances are higher than 15 per cent.[172]

We therefore use the rate of 15 per cent to estimate the retail margin. This is applied to the change in variable costs as identified above.

Gas costs

AER publishes NEM electricity wholesale prices and East Coast gas wholesale prices in its *Wholesale Markets Quarterly*. According to the latest issue of the Quarterly, the average quarterly wholesale price in NEM ranged from $64 per MWh in Victoria to

171 AER, *Default market offer prices 2022-23: Final determination*, May 2022, Australian Energy Regulator, https://www.aer.gov.au/system/files/AER%20-%20Default%20Market%20Offer-%20Price%20determination%202022-23%20-%20Final%20Determination%20-%2026%20May%202022.pdf, p.45

172 AER, *Default market offer prices 2023-24: Final determination*, May 2023, Australian Energy Regulator, https://www.aer.gov.au/system/files/Default%20market%20offer%20prices%202023-24%20final%20determination.pdf, p.42, Table 8.1.

$114/MWh in Queensland in March 2023, compared to the highs of $241-344/MWh in June quarter of 2022.[173] For gas, the wholesale prices in the East Coast market has fallen from over $40 per gigajoule (GJ) on average in July 2022 to below $12/GJ in March quarter of 2023.[174]

WA Department of Mines, Industry Regulation and Safety (DMIRS) publishes price data on major commodity resources including domestic gas.[175] The average domestic price in 2022 was $5.46/GJ.

Energy price forecasts

Forecasting energy price is a multifaceted undertaking that exceeds the scope of this analysis. Therefore, we will rely on established energy price forecasts available from reliable sources.

AEMO provides comprehensive price indexes for commercial electricity, extending across a significant time horizon under different scenarios.[176]

As discussed above, the Step Change scenario is most relevant because it is the most likely scenario identified by AEMO. Charts B.15 illustrates the electricity price index for commercial customers by NEM states under the Step Change scenario.

For the 2023 Gas Statement of Opportunities (GSOO), Lewis Grey Advisory (LGA) prepared forecast of wholesale and delivered prices up to 2053 under different scenarios.[177] Chart B.16 illustrates the delivered gas prices (weighted oil indexed) for Eastern Australian markets under the Step Change scenario.

Price forecasts for WA and the NT are unavailable. As a result, we rely on the NEM average price index for these regions.

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173 Australian Energy Regulator (AER) 2023a, *Wholesale markets quarterly – Q1 2023*, 20 April 2023, Figure 1, p.6, https://www.aer.gov.au/wholesale-markets/performance-reporting/wholesale-markets-quarterly-q1-2023, accessed 14 October 2023.

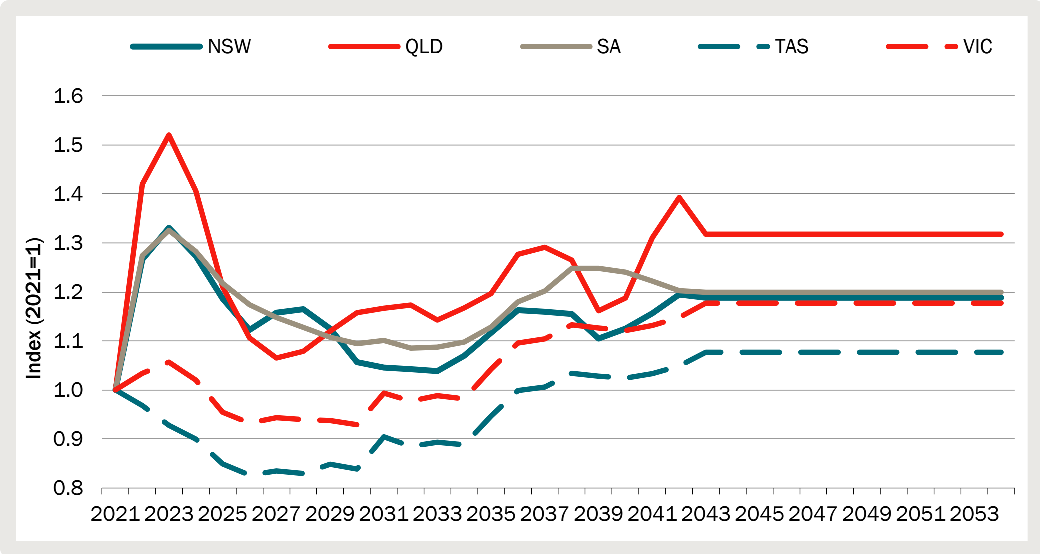
174 AER 2023b, *Wholesale markets quarterly – Q4 2022*, 16 February 2023, Figure 1.8, https://www.aer.gov.au/wholesale-markets/performance-reporting/wholesale-markets-quarterly-q4-2022; and AER (2023a), op.cit., Figure 6, p.10.

175 Department of Mines, Industry Regulation and Safety, 'Latest statistics release', in *2022 Major commodities resources data*, 2022, https://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx, accessed 3 November 2023.

176 AEMO, *National Electricity and Gas Forecasting*, 2022, http://forecasting.aemo.com.au/Electricity/AnnualConsumption/Operational, accessed 2 October 2023.

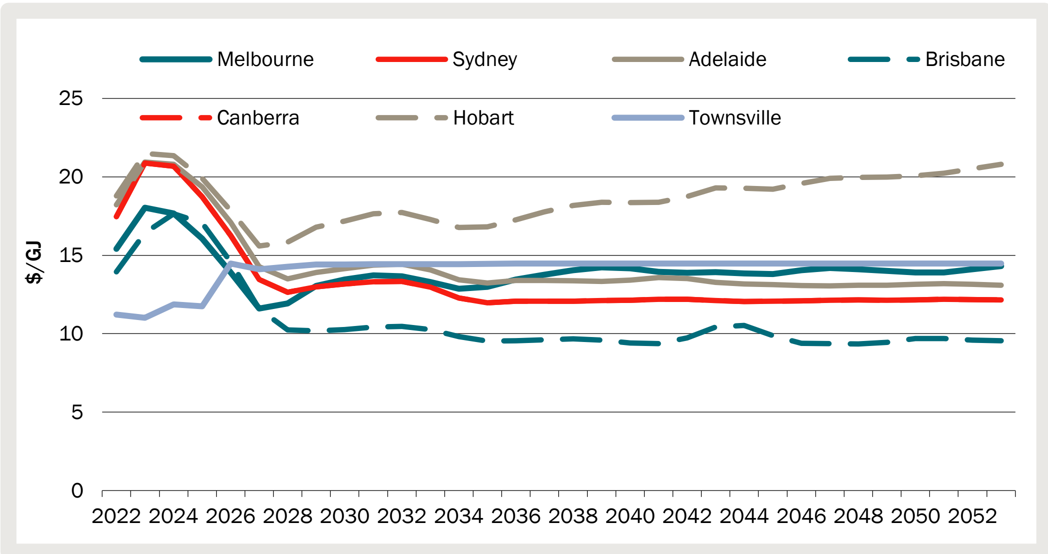
177 Lewis Grey Advisory (LGA), *Gas Price Projections for Eastern Australia, 2023 Update*, prepared for Australian Energy Market Operator, 14 December 2022, https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo, accessed 2 October 2023.

B.15 Electricity price index for commercial customers under Step Change scenario



Data source: AEMO (2022).

B.16 Gas delivered price for residential and commercial customers under Step Change scenario

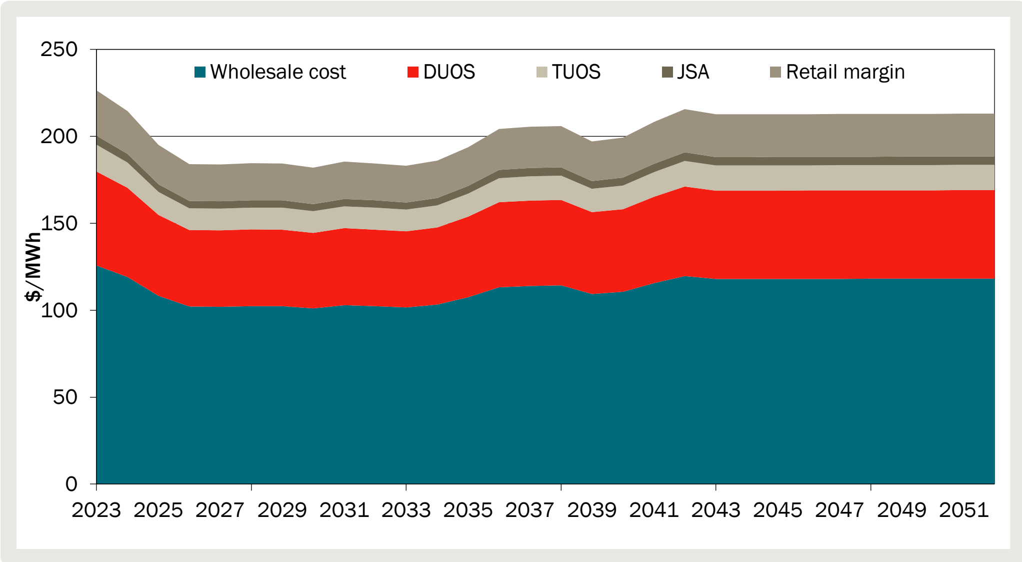


Data source: LGA (2022).

We use these indexes or price forecasts as a basis for forecasting future energy prices. Charts B.17 to B.19 illustrate the national average price series up to 2054.

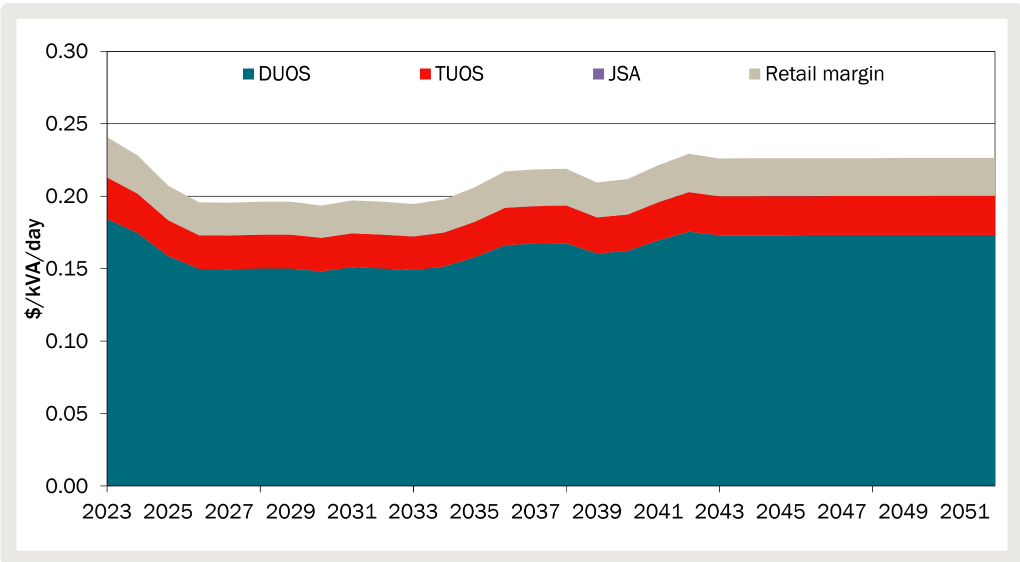
In the CBA modelling for the RIS, we apply the projected change in the retail price for each jurisdiction across all the relevant components.

B.17 Electricity consumption tariff forecast



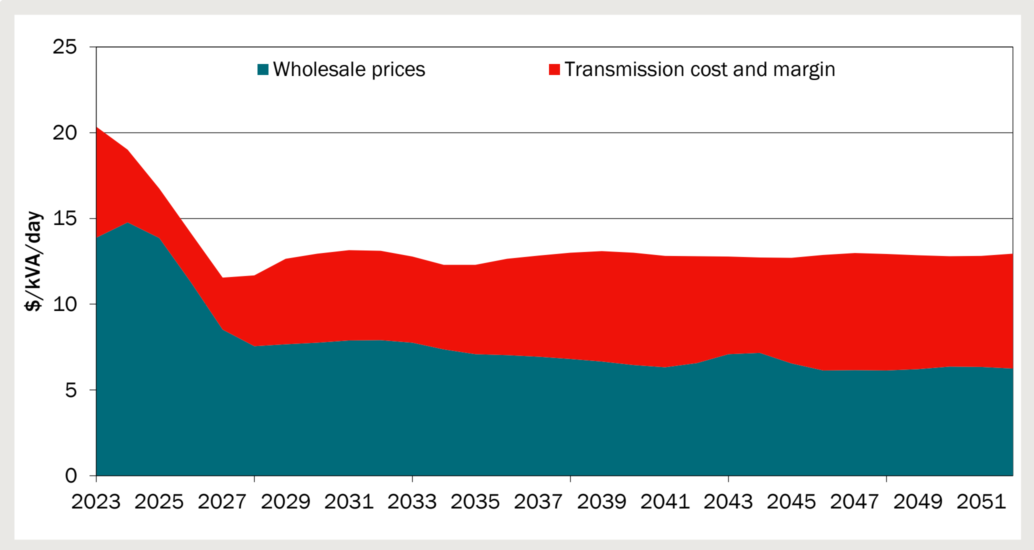
Data source: CIE estimates.

B.18 Electricity demand/capacity charge forecast



Data source: CIE estimates.

B.19 Gas price forecast



Data source: CIE estimates.

C *Are modelled energy savings realised in practice?*

The performance gap

A well-known issue covered extensively in the international literature is that a building's actual energy consumption tends to exceed model-based estimates of energy consumption. This is often referred to as the 'performance gap'. The performance gap appears to be a more significant issue in commercial (non-residential) buildings, compared with residences.[178]

Treatment in the 2018 RIS

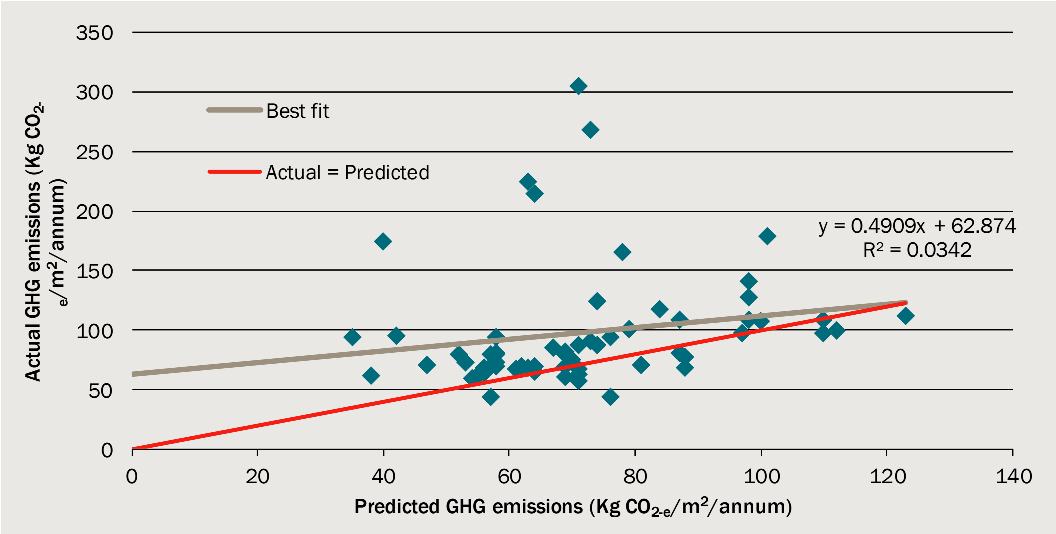
Although the performance gap was a well-known issue, the 2018 RIS (prepared by CIE) was the first Australian RIS (or cost-benefit analysis) of energy efficiency regulation to have addressed the issue of whether modelled energy savings are achieved in practice. In particular, the 2018 RIS:

- presented evidence from several international (peer reviewed) papers that suggested that predicted energy savings in buildings designed to be more energy efficient may not be achieved in practice. For example, Frankel and Turner (2008) noted that projects with more aggressive energy performance goals generate overly optimistic predictions of actual energy use.[179] This suggests that predicted energy savings may not be achieved in practice.
- presented a re-analysis of data published by GBCA.

178 International Partnership for Energy Efficiency Cooperation (IPEEC) Building Energy Efficiency Taskgroup, 2019, *Building Energy Performance Gap Issues: An International Review*, p. 16.

179 Frankel, M. and Turner, C. 2008a, "How Accurate is Energy Modelling in the Market", New Buildings Institute, *2008 ACEEE Summery Study on Energy Efficiency in Buildings*, pp. 3-90—3-95.

C.1 Relationship between predicted and actual GHG emissions (from 2018 RIS)



Data source: CIE based on data in Bell, H., Millagre, R. and Sanchez, C. 2013, *Achieving the Green Dream: Predicted vs Actual*, Green Building Council of Australia, August 2013, pp. 17-20.

Key limitations of the analysis included the following.

- The analysis did not take into account the extent to which the difference between predicted and actual outcomes was due to factors such as actual occupancy patterns varying from the modelling protocols.
- The sample covers only a subset of office buildings (i.e. office buildings with both a Green Star rating and a NABERS rating) and was unlikely to be representative of all commercial buildings.

Given the uncertainty around the performance gap, CBA results were presented under various realisation assumptions, as follows.

1 Under the first (low) realisation scenario, it was assumed that 49 per cent of modelled energy savings would be achieved in practice. This was consistent with the relationship between modelled and actual GHG emission savings implied by the Green Star data (see chart C.1 above).

2 Under the second (medium) realisation scenario, 75 per cent of modelled energy savings were assumed to be achieved in practice. This was consistent with the relationship between modelled and actual GHG emissions implied by the Green Star data when the five outliers have been excluded from the sample.

3 Under the third (high) realisation scenario, modelled energy savings were assumed to be achieved fully in practice.

Relevance of the performance gap to the RIS

As energy modelling forms the primary evidence base to support the proposed changes to the minimum energy efficiency requirements in NCC, it is critical to examine whether this evidence is a reliable indicator of the actual impacts of the proposal.

The modelling for the NCC 2025 update for the Department of Industry, Science and Resources (DISR) argued that any discount applied to energy consumption[180] in the policy case (i.e. the proposed energy efficiency provisions for NCC 2025) should also be applied in the base case (i.e. NCC 2019) to avoid unfairly penalising the policy case.[181]

However, this misinterprets the evidence cited in the RIS.

- In particular, the above analysis (see chart C.1)[182] found that on average, the (absolute) performance gap tends to be much higher in energy efficient buildings (i.e. buildings with low modelled energy intensity), compared with less energy efficient buildings (i.e. building with higher modelled energy intensity).
- This relationship implies that the performance gap is likely to be higher for a building under the policy case (i.e. compliant with NCC 2025), compared with the base case (i.e. compliant with NCC 2019).
- The implication would be that the modelled energy *savings* (i.e. the difference between NCC 2019 and NCC 2016) are unlikely to be fully realised on average (i.e. the slope of the line of best fit is less than 1).

If, as argued in the commercial buildings update report, the 'performance gap' (in absolute terms) is likely to be the same in the base case (i.e. NCC 2019) and the policy case (the NCC 2025 proposal), we would expect the line of best fit (i.e. the grey line in chart C.1) to have a slope close to 1 (i.e. parallel to the red line where actual energy consumption equals predicted energy consumption).

Recent evidence

Over recent years (i.e. since the 2018 RIS), there has been significant research to understand the performance gap from both a technical and a policy perspective.

Much of the literature focuses on estimating the size of the performance gap using various building samples and the causes of the performance gap, rather than the central question to the RIS: whether modelled energy *savings* are achieved in practice.

180 Note that the report refers to applying a discount to 'energy savings' in both the base case and the policy case. However, this makes little sense as 'energy savings' refers to the difference between energy consumption in the policy case compared to the base case.

181 See for example: DeltaQ and Strategy.Policy.Research. *Commercial Buildings Low-Energy Trajectory*, NCC 2025 Update to Achieving Low Energy Commercial Buildings in Australia, Final Report, 10 March 2022, p. 92.

182 Although the data relate to GHG emissions, rather than energy consumption, GHG emission estimates are based on the energy consumption and the emissions intensity of the relevant energy sources in each building's location. The emissions intensity of each energy source is unlikely to have varied significantly from the predictions. The relationship is therefore likely to be indicative of the relationship between predicted and actual energy consumption, unless prediction errors can be explained by a significant shift in the energy mix (i.e. between electricity and gas).

Recent work for the International Partnership for Energy Efficiency Cooperation (IPEEC) Building Energy Efficiency Taskgroup (BEET) noted that building energy modelling can be a powerful tool for understanding the likely impacts of different building system alternatives, construction practices, and occupant behaviour issues. However, building energy models are generally not intended to "predict" actual energy performance when the building is operational.

According to the IPEEC report, energy modelling during the building's design phase is most commonly used to demonstrate compliance with 'a building code or other regulatory instrument, which typically covers only a subset of energy uses (referred to as 'regulated uses'). In operation, buildings often incur other loads which are not regulated (such as appliances, elevators, process loads, or other plug loads) which can be significant. These uses are often not captured accurately in compliance-oriented energy models.[183] This implies that comparisons between modelled and actual energy consumption may not be an 'apples with apples' comparison.

Of relevance to the RIS, the IPEEC report noted increasing evidence of expected savings from retrofit projects not being realised.[184] The evidence from retrofit projects is important because the 'base case' (i.e. the building's performance prior to the retrofit) can be observed. By contrast, the base case (i.e. a hypothetical less energy efficient alternative building) cannot be directly observed for new buildings (as discussed below it can be challenging to compare across buildings).

In the Australian context, an important recent contribution to understanding the performance gap is the GBCA's recent report *Green Star in focus: Energy performance in Green Star buildings: Closing the performance gap in Australia's commercial office sector*. This report was an update and expansion of a previous (2013) report *Achieving the Green Dream: Predicted vs. Actual – Greenhouse Gas Performance in Green Star certified office buildings,* the research report that provided the data that CIE used as the basis for our analysis (see chart C.1 above).

The main objective of the new study was to verify how predictive energy modelling applied to the design of Green Star rated buildings translates into performance in operations. The analysis compared modelled and actual performance of 176 office buildings (this compared to a sample of 70 buildings for the 2012 report) with both:

- a Green Star rating (which includes modelled outcomes); and
- a NABERS Energy (base building) rating (which reports actual outcomes).

Modelled energy performance was taken from Green Star project submissions and converted to a NABERS star rating using the NABERS Energy Calculator. This was then compared to the actual NABERS Energy rating from the NABERS database.

The analysis focuses on the NABERS Energy ratings (rather than energy intensity) because it corrects for unavoidable operational factors, such as hours of occupancy

183 International Partnership for Energy Efficiency Cooperation (IPEEC) Building Energy Efficiency Taskgroup, 2019, *Building Energy Performance Gap Issues: An International Review*, p. 1.

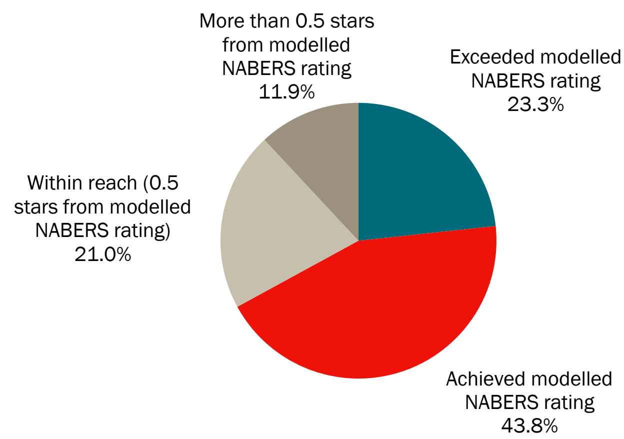
184 IPEEC Building Energy Efficiency Taskgroup (2019), op. cit., p. 14.

(i.e. where a building's actual hours of occupancy are greater than modelled, the building will use more energy).[185]

The GBCA found that (see chart C.2):[186]

- 88 per cent of buildings in the sample achieved, exceeded or were within reach of their modelled NABERS Energy rating, including:
- 23 per cent improved on their modelled NABERS Energy rating
- 44 per cent achieved their modelled NABERS Energy rating
- 21 per cent were within 0.5 starts of their modelled NABERS Energy rating
- 12 per cent of buildings were more than 0.5 stars from their modelled NABERS Energy rating.

C.2 Comparison of actual and modelled NABERS rating



Data source: Green Building Council of Australia, 2021, *Green star in focus: Energy performance in Green Star buildings: Closing the performance gap in Australia's commercial office sector*, pp. 56-57.

These results were an improvement from the previous (2012) analysis (see chart C.3):

- a greater proportion of buildings in the sample achieved or exceeded the modelled NABERS rating
- a smaller proportion of buildings in the sample performed significantly below the modelled NABERS rating.

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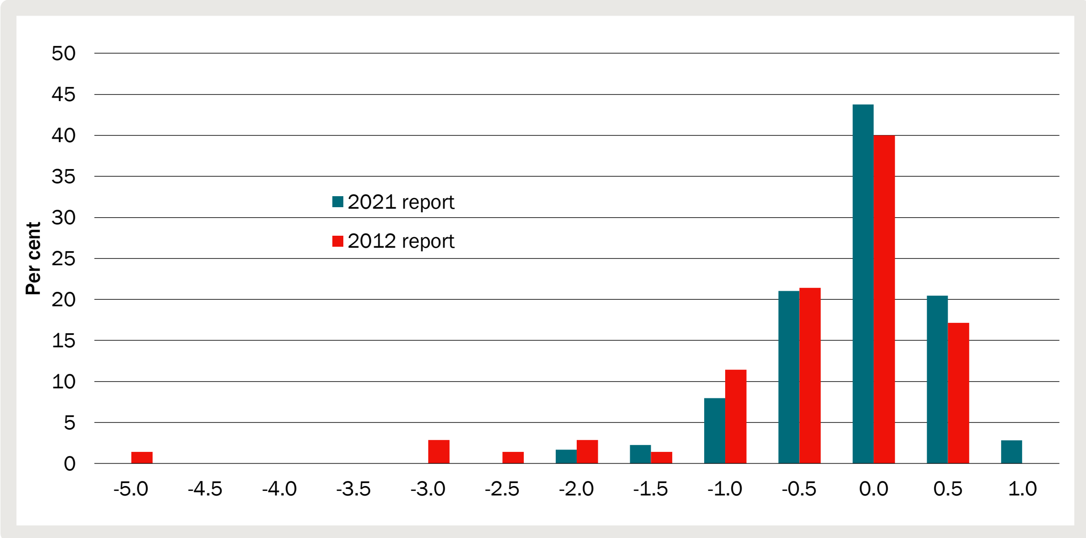
185 Green Building Council of Australia (GBCA), 2021, *Green Star in focus, Energy performance in Green Star buildings, Closing the performance gap in Australia's commercial office sector*, p. 01.

186 GBCA (2021), op. cit., p. 3.

C.3 Comparison of actual and modelled NABERS rating — frequency distribution



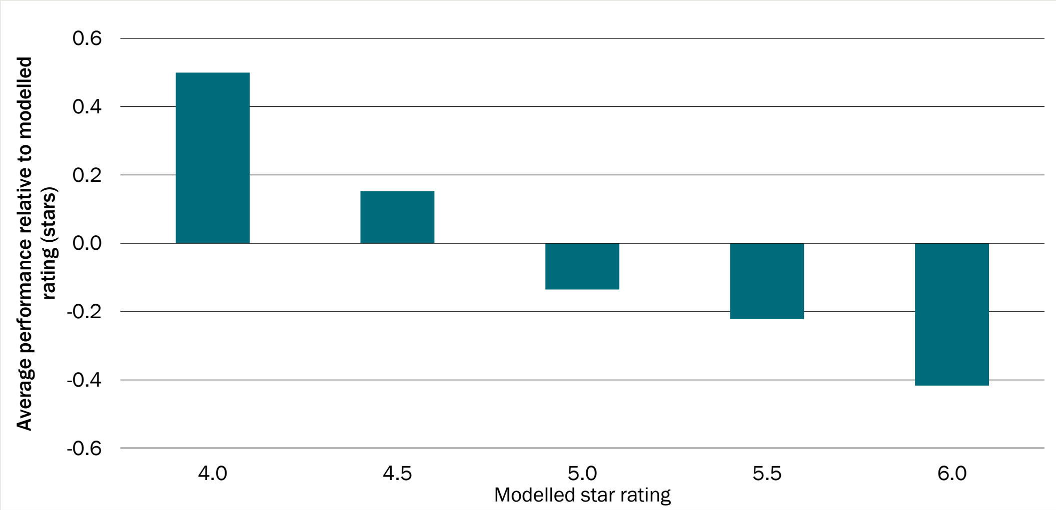
Data source: CIE based on: Green Building Council of Australia, 2021, *Green star in focus: Energy performance in Green Star buildings: Closing the performance gap in Australia's commercial office sector*, pp. 56-57; and Bell, H., Millagre, R. and Sanchez, C. 2013, *Achieving the Green Dream: Predicted vs Actual*, Green Building Council of Australia, August 2013, pp. 17-20.

Although the improvement in actual performance relative to modelled outcomes is a welcome development, there is nonetheless some evidence within the data that buildings designed to be more energy efficient are not achieving the intended savings. As discussed above, this is the key issue of relevance to the RIS.

In particular, the data suggests the following (see chart C.4).

- Buildings that are designed to be less energy efficient (i.e. the modelled star rating is lower) tend to over-perform (i.e. achieve a higher star rating than modelled).
- Buildings that are designed to be more energy efficient (i.e. the modelled star rating is higher) tend to under-perform (i.e. achieve a lower star rating than modelled).

C.4 Comparison of modelled and actual NABERS star rating by modelled star rating



Data source: CIE based on data reported in Green Building Council of Australia, 2021, *Green star in focus: Energy performance in Green Star buildings: Closing the performance gap in Australia's commercial office sector*.

An important caveat on this analysis is the small sample of buildings at either end of the spectrum. In particular: there were only 2 buildings that were modelled to achieve 4 stars (both of which achieved 4.5 stars); and only 6 buildings that were modelled to achieve 6 stars. Nevertheless, this bias implies that more energy efficient buildings are unlikely to fully achieve the expected energy savings.

Furthermore, a subsequent scoping study investigating the Building Energy Performance Gap (BEPG) found that it is not appropriate to extrapolate from findings in relation to the performance gap based on the GBCA's 2021 dataset to other building types for the purposes of regulatory impact analysis.[187]

- The scoping study argues that the BEPG in well-designed and well-managed office buildings has been materially resolved through their participation in rating systems that measure both design and performance.
- The performance gap in other types of buildings that are not captured by these rating systems remains unquantified and poorly understood.

As part of the scoping study, the authors reviewed potential data sources across a broader range of building types that could be used to investigate the issues relating to the performance gap in subsequent phases of the research.

The project encountered significant challenges obtaining relevant data, ultimately concluding that:

187 Green Building Council of Australia (GBCA) 2022, *Building Energy Performance Gap NCC 2025 — Scoping Study*, August 2022, pp. 5-6.

- JV3 energy modelling cannot be used to extrapolate total energy use.[188] In particular, the following factors limited the usefulness of JV3 reports for analysing the performance gaps:[189]
  – The typical design and construction process means that the final systems have not been confirmed when the JV3 energy simulation is completed.
  – JV3 is used as a tool to enable comparisons between alternate designs, allowing projects to confirm building aesthetics and tender pricing for building fabric. It is not used by industry as a performance measurement tool.
- This means that a study comparing energy use estimates from JV3 assessment reports with actual outcomes would not be comparing like with like.
- There is no data currently available within industry that could be aggregated to create an appropriate dataset.[190]

Based on these findings it seems unlikely that a robust estimate of the extent to which modelled energy savings associated with more stringent energy efficiency standards will be realised in practice or will be available in the near term.

Reasons for the performance gap

There are a range of explanations for the performance gap at all stages of a building's life cycle.

- Design and construction phase — the NCC focuses on building design, but there can be gaps between a building's design and the building actually constructed.
- The National Energy Efficient Buildings Project also noted that anecdotally, energy efficiency features and technologies are eliminated during the design and construction process. Budget constraints often force the building developer (not necessarily the ultimate owner) to choose between energy performance and other design elements that are more highly valued.[191] However, no quantitative evidence on the extent to which this occurs was reported.
- The United Kingdom Carbon Trust also noted that:
  – the aim to make building low carbon in-use is not clearly conveyed to the design team, and
  – design intent is not delivered on-site during construction. [192]

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[188] GBCA (2022), op. cit., p. 6.

[189] GBCA (2022), op. cit., p. 16.

[190] GBCA (2022), op. cit., p. 7.

[191] pitt&sherry 2014, *National Energy Efficient Building Project: Final report*, report prepared for Department of State Development, Government of South Australia, November 2014, pp. 65-66.

[192] Carbon Trust 2011, *Closing the gap: Lessons learned on realising the potential of low carbon building design*, p. 4.

- Operation phase — building operation could contribute to the performance gap, including:
  - A lack of adequate commissioning and maintenance — the National Energy Efficient Buildings Project reported that a perceived lack of adequate commissioning for new and renovated commercial buildings and ongoing maintenance was likely to be contributing to poor energy efficiency outcomes. As buildings aim for higher energy efficiency, integrating all of the relevant systems and ensuring that they deliver intended outcomes, through all seasons and weather conditions becomes more challenging. This means there is often greater scope for high performance buildings to deviate from design energy consumption than simpler, 'refrigerated boxes'.[193] This finding was based on industry perceptions, rather than quantified evidence.
  - Sub-optimal building operation — one stakeholder noted that there is less 'margin for error' in buildings with more energy efficient equipment. This could imply that sub-optimal building operating practices have a greater impact in more energy efficient buildings.
  - Occupancy patterns and behaviour — occupancy patterns can be difficult to predict and where they vary from those modelled, this could contribute to the performance gap. Similarly, the behaviour of building occupants can have a significant impact on energy consumption. Although several reports have found that occupant behaviour was a key driver of the 'performance gap', a recent analysis found no conclusive and sufficient empirical evidence supporting the claim that occupants' behaviour is responsible for the bulk of building-related energy performance gap.[194]
  - Modelling failures — a recent United Kingdom study (albeit in relation to residential buildings) found that a sample of 108 building modellers found that there was little correlation between variables that the modellers considered to be important to annual energy demand and the factors that were objectively found to be important.[195] On this basis, the study concluded that this sample of building modellers, and by implication the population of building modellers cannot be considered 'modelling literate'. This suggested that the performance of building modellers was contributing to the performance gap. Although these findings have no direct relevance to commercial building energy modellers in Australia, it nonetheless demonstrates that energy modelling involves subjective judgement and modellers are not infallible.

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193 pitt&sherry 2014, *National Energy Efficient Building Project: Final report*, report prepared for Department of State Development, Government of South Australia, November 2014, pp. 65-66.

194 A Mahdavi et al., 'The Role of Occupants in Buildings' Energy Performance Gap: Myth or Reality?', in *Sustainability*, vol. 13, 2021, 3146.

195 Imam, S. Coley, D.A. and Walker, I. 2017, "The building performance gap: Are modellers literate?", *Journal of Building Services Engineering Research & Technology*, **38**(3), pp.351-375.

D Impact of EV charging facilities

A requirement to provide EV charging infrastructure at commercial buildings may increase or bring forward the provision of such charging infrastructure relative to the base case. Demand for EVs themselves may be increased as a result (due to network effects). Increased market share for EVs relative to internal combustion vehicles will result in fewer carbon emissions in Australia, a trend that will accelerate as electricity generation is decarbonised. This reduction in emissions may increase the likelihood that Australia will meet its obligations under international agreements to successfully reduce global emissions, resulting in mitigation of climate change. This is a positive externality from the provision of EV charging infrastructure at commercial buildings.

The question of whether the requirement to provide charging infrastructure is worthwhile will come down to whether the cost is higher than the forecast value of emissions reduction (using a SCC) or the marginal cost of achieving the abatement another way. Some authors have argued that subsidising charging infrastructure has a greater impact on EV adoption than subsiding EVs themselves and results in fewer distortions.[196, 197]

The costs and benefits of the proposed NCC requirements would be measured relative to a base case scenario without changes to the Code.

In each year, benefits will be measured as:

- the use value placed on additional charging infrastructure.
  - Base case EV user willingness to pay (WTP) for improved availability/charge times (Area A in figure D.1),[198] plus
  - A proportion (typically half) of the same WTP for users switching from conventional to EV between the base case and change scenarios (Area B in figure D.1, which is around half the area of B+C)
- the value of avoided emissions, which results from the increased market share for electric vehicles and reduced market share for conventional vehicles.

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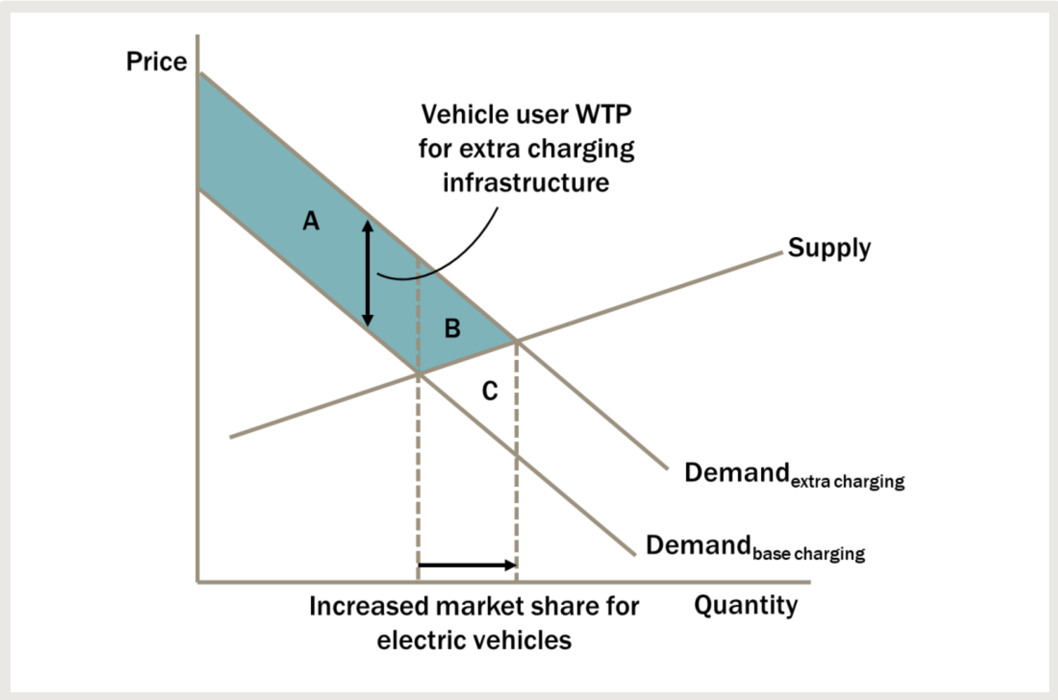
[196] Li, S., Tong, L., Xing, J. and Zhou, Y., 2017, 'The market for electric vehicles: indirect network effects and policy design', *Journal of the Association of Environmental and Resource Economists*, 4(1), pp.89-133.

[197] Remmy, K., 2022, *Adjustable product attributes, indirect network effects, and subsidy design: The case of electric vehicles* (No. crctr224_2022_335), University of Bonn and University of Mannheim, Germany.

[198] This item (Area A) is presumably below cost, otherwise the charging infrastructure would be provided in the baseline. The question is whether the external benefits of avoided emissions outweigh the shortfall.

D.1 Market for electric vehicles



Data source: CIE.

To calculate these benefits, we need to forecast, for both the baseline and change scenarios:

- EV user WTP for charging infrastructure by vehicle type, which requires forecasts of:
  - availability of charging infrastructure
  - charge time at charging infrastructure, and
  - EV battery range by vehicle type
- EV market share/number of users by vehicle type
- emission intensity of conventional vehicles
- emission intensity of EVs, and
- the value of avoided emissions.

Our assumptions in relation to the baseline scenario will be consistent with commitments made in the National Electric Vehicle Strategy released in April 2023. Each of these items is discussed further below.

EV user willingness to pay

EV user WTP for additional charging infrastructure in the change scenarios relative to the baseline scenario will be estimated using the CIE's 2019 choice modelling study conducted for Australian Automobile Association (AAA).[199] Estimates of average WTP per consumer in the vehicle purchase price (across all vehicle types) for improvements in charging time are set out in table D.2.

D.2 Average willingness to pay for a marginal change in vehicle/charging attributes

Attribute	Unit	Marginal WTP (2019$ in purchase price)
Carbon emissions	per 50 g/km (decrease)	244
Destination charging time	Change from 120 to 60 minutes	686
Destination charging time	Change from 60 to 15 minutes	25
Highway charging time	Change from 60 to 30 minutes	1,350
Highway charging time	Change from 30 to 15 minutes	1,137
Highway charging time	Change from 15 to 5 minutes	1,120

All vehicle types n=3021, reweighted to account for oversampling of persons with university degrees

Source: CIE 2019. Demand for electric vehicles – a discrete choice survey. Final Report prepared for Australian Automobile Association, 22 January.

In the CIE model, the WTP for additional availability of charging infrastructure depends on EV battery range. Estimates for selected levels of battery range are set out in table D.3.

D.3 Average willingness to pay for improvements in availability of charging (2019$)

Battery range (km)	Availability of charging on major highways (every 300 km to every 200 km)	Availability of charging on major highways (every 200 km to every 100 km)	Availability of charging at major shopping centres and commercial car parks (per 10 percentage points)
150	4,782	2,107	382
230	3,602	927	228
320	2,691	16	109

All vehicle types n=3021, reweighted to account for oversampling of persons with university degrees

Note: Assumes vehicle is a battery electric vehicle, rather than a plug-in hybrid electric vehicle

Source: CIE 2019. Demand for electric vehicles – a discrete choice survey. Final Report prepared for Australian Automobile Association, 22 January.

Charging availability

There are many factors influencing the provision of charging infrastructure in new commercial developments, including vehicle manufacturer and energy retailer initiatives and interventions at all levels of government. The starting point for our

[199] CIE, *Demand for electric vehicles: A discrete choice survey*, a report for Australian Automobile Association, 22 January 2019, https://www.thecie.com.au/s/CIE-AAA-EV-choice-final-report-public.pdf

forecast will be a continuation of the historical trend in availability of charging infrastructure. The forecast will be checked for consistency with the assumptions made by CSIRO in its EV projections for AEMO. CSIRO has not made explicit assumptions about charging availability. However, CSIRO assumes, based on transport analysis and evidence from overseas, that 10 per cent of EV charging will occur at public fast chargers (table D.4). The CIE will review the availability of charging in the countries from which this figure was derived.

D.4 CSIRO maximum market share prior to internal combustion engine vehicle collapse

Scenario	Progressive change Per cent	Exploring alternatives Per cent	Step change Per cent	Hydrogen export Per cent
Maximum market share prior to ICE vehicle collapse				
Public or multi-occupant building charging availability[a]	40	50	65	80
Off-street parking/private charging availability	26	32	35	42
Share of charging behaviour				
Public charging highway fast charge	10	10	10	10
Public charging solar aligned	16	19	22	21

a Availability here means at your work/regular daytime parking area, apartment carpark or in your street outside your house. Assumptions are based on this type of charging being the least financially viable.

Source: CSIRO 2022. Electric vehicle projections 2022. Commissioned for AEMO's draft 2023 input, assumptions, and scenarios report. November.

Availability of public charging infrastructure under the change scenarios will be informed by forecasts of new and renovated commercial buildings as a proportion of the stock of commercial buildings and the proposed requirements under the Code.

Charging times

Assumptions about baseline charging times, specifically the time taken to recharge batteries to 80 per cent, will be developed by the CIE with reference to any relevant assumptions made by CSIRO in its EV projections for AEMO. Charge time under change scenarios will be informed by proposed requirements under the Code. If assumptions about charge times are not available from these sources, a range of levels will be used to test sensitivity to this parameter.

Electric vehicle battery range

EV battery range will be forecast based on a review of literature. For example, International Energy Agency (IEA)'s Global EV Outlook 2020 assumed that by 2030 EVs will "reach an average driving range of 350-400 km."

Number of users by vehicle type

The CIE will establish baseline projections of both the flow of new EV and conventional vehicles and the stock of EV and conventional vehicles based on CSIRO's EV projections for AEMO.

The increase in EV market share resulting from the increased availability (and potentially charge times) of charging infrastructure under the scenarios being evaluated will be estimated using The CIE's model of vehicle demand derived using a choice modelling survey conducted for the Australian Automobile Association in 2019. In practical terms, The CIE will construct a vehicle demand model containing baseline levels for the parameters discussed in the sections above and solve for the forecast EV purchase price each year such that the market share is calibrated to the CSIRO forecast. The model will be used to estimate the change in market share that occurs when charging infrastructure attributes are improved under the scenarios (assuming perfectly elastic supply).

Emission intensity of conventional and electric vehicles

Emission intensity of new conventional vehicles will be assumed to improve in line with the historical trend of roughly one per cent per year (driven by improvement in fuel efficiency). The changes in emissions intensity of the stock of conventional vehicles will therefore change very slowly.

Emission intensity of electric vehicles will be forecast based on:

- the emissions trajectory in the 'Step Change' scenario of AEMO's Integrated System Plan 2022, and
- gradual improvement in the efficiency (kWh per km) of new EVs (to be informed by historical trends and a literature review).

It will take account of the load profile for EVs and carbon intensity by time of use to the degree that reliable data are available.

Value of avoided emissions

The value of emission reduction would be applied consistently with the approach taken elsewhere in the RIS.

Avoided electricity costs

If there are significant avoided electricity costs from charging during the day rather than at night, then many of these costs will be avoided in the baseline scenario through voluntary provision of destination charging infrastructure to meet demand for low-cost charging. The drivers who most value daytime charging will utilise it in the baseline scenario. The proposal scenario will involve some switching from conventional to electric vehicles, which will increase demand for electricity and decrease demand for petrol and diesel. It may also shift some electricity load from night to daytime. The difference between off-peak and solar sponge prices is relatively small; however, there is a potential benefit in principle. We will consider whether including this benefit is warranted once the relevant inputs and assumptions have been quantified.

E Modelled building archetypes and climate zones

Modelled building archetypes

10 archetypes have been modelled:

- Hotels (C3HL)
- Motels (C3HS)
- Large office building (C5OL)
- Medium office building (C5OM)
- Small office building (C5OS)
- Big box retail (C6RL)
- Strip shops (C6RS)
- Large hospital ward (C9A)
- School classroom block (C9B)
- Aged care facility (C9C)

For more information, please see the mobilisation report by DeltaQ.[200]

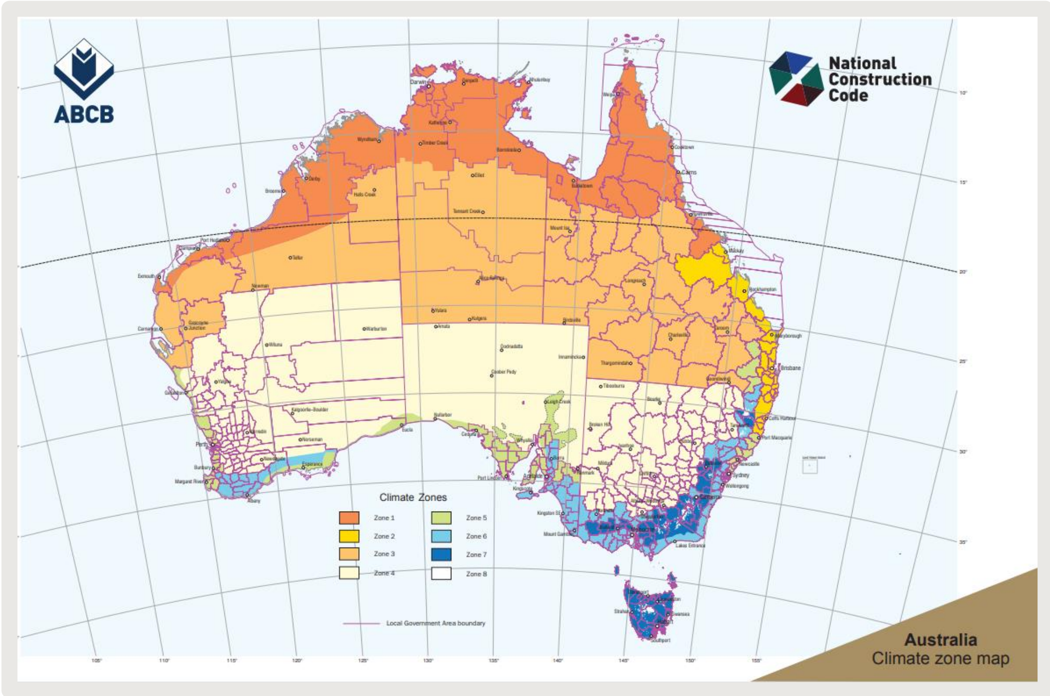
NCC climate zones

The NCC defines 8 Climate zones as follows (see chart E.1:

- Climate Zone 1 — high humidity summer, warm winter
- Climate Zone 2 — warm humid summer, mild winter
- Climate Zone 3 — hot dry summer, warm winter
- Climate Zone 4 — hot dry summer, cool winter
- Climate Zone 5 — warm temperate
- Climate Zone 6 — mild temperate
- Climate Zone 7 — cool temperate
- Climate Zone 8 — alpine.

200 DeltaQ 2023, *EE NCC 2025 – Advice on the technical basis: Mobilisation report*, report to the Australian Building Codes Board (ABCB), 14 June 2023.

E.1 NCC climate zones



Data source: ABCB website, https://www.abcb.gov.au/sites/default/files/resources/2022/Climate-zone-map-aust.pdf, accessed 3 January 2024.

F Modelled electricity savings by time of day

The value of electricity saved depends on the time of day (as reflected in electricity tariffs). This appendix presents charts showing modelled electricity savings by time of day throughout an average week (averaged across every week in each season) for building type and climate zone under Stringency Level 1 and Stringency Level 2. To save space, only electricity savings for large office building and large hospital ward in Climate Zones 2, 5 and 6 are presented.

These charts show clear distinct patterns of energy savings across different time of the day, seasons, building type (mainly daytime only use versus day and night use buildings) and climate zones.

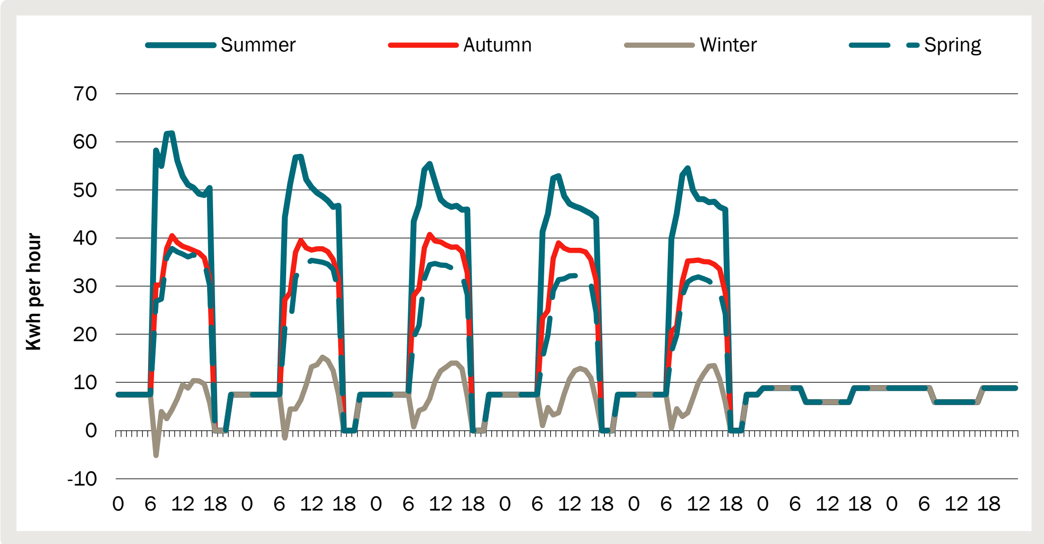
- For the daytime-operating buildings — the large office building (C5OL):
  - the largest savings are estimated to occur during working hours (approximately 7am to 6pm on weekdays), reflecting building occupancy and therefore energy consumption patterns)
  - electricity savings tend to be greatest over the summer months (although this varies across climate zones).
- For the buildings that operate during the daytime and night-time (the hospital ward):
  - electricity savings tend to be greatest during the afternoons and evenings on both weekdays and weekends, although the timing of the peaks varies across climate zones
  - for the aged care facility, there is also a winter peak that occurs during the night from around 10 pm through to around 9 am in some climate zones (reflecting the use of electricity for heating).

Large office building

Energy savings by time of day for the large office building archetype (C5OL) in selected climate zone for Stringency Level 1 and Stringency Level 2 are shown in the charts below.

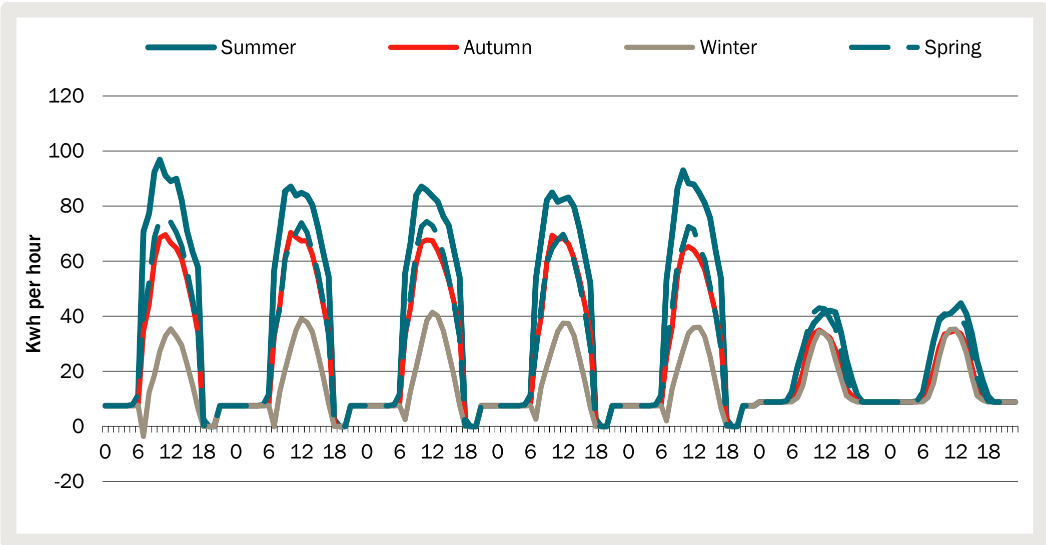
Climate zone 2

F.1 Energy savings by time of day — Stringency Level 1, large office in CZ2



Data source: DeltaQ modelling, CIE.

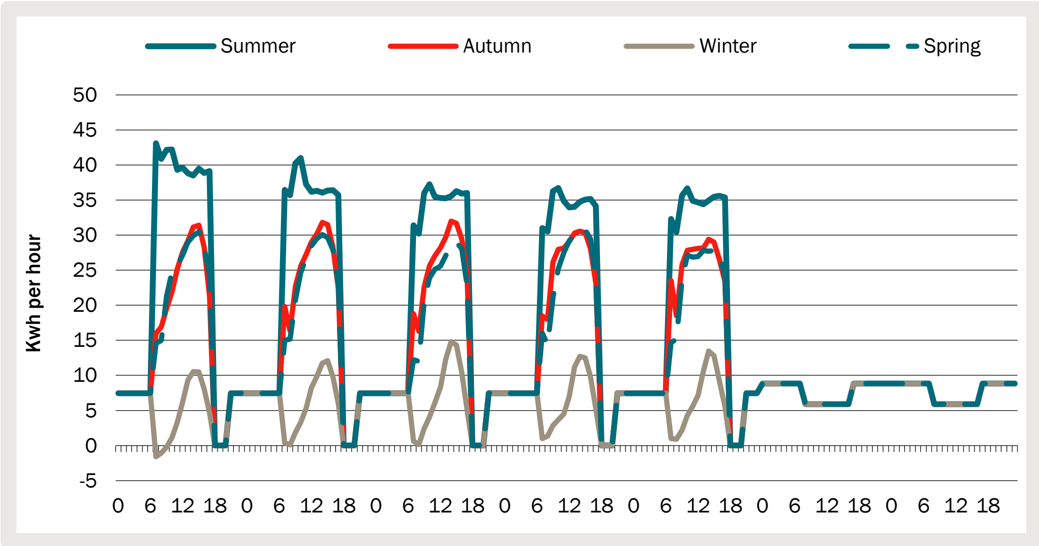
F.2 Energy savings by time of day — Stringency Level 2, large office in CZ2



Data source: DeltaQ modelling, CIE.

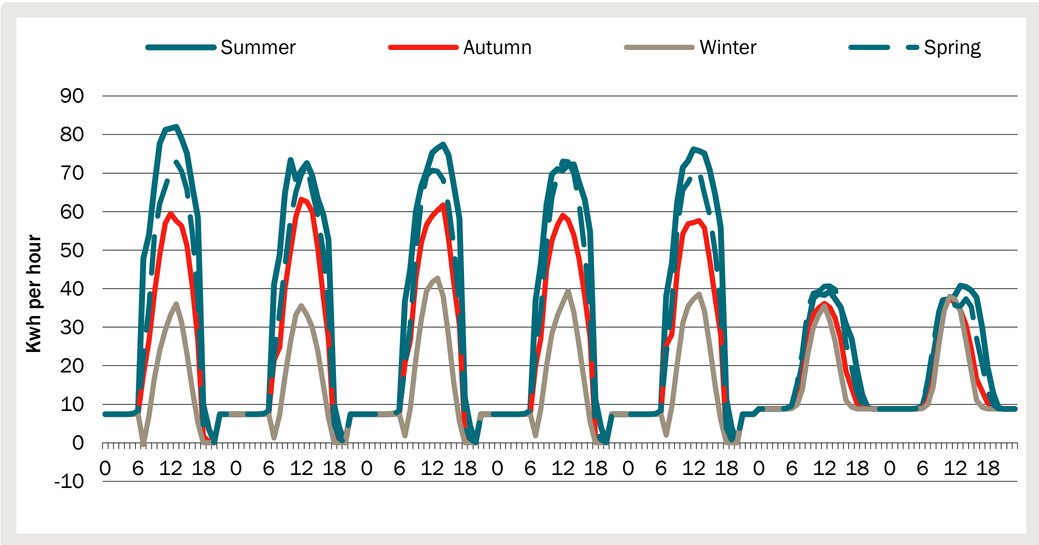
Climate zone 5

F.3 Energy savings by time of day — Stringency Level 1, large office in CZ5



Data source: DeltaQ modelling, CIE.

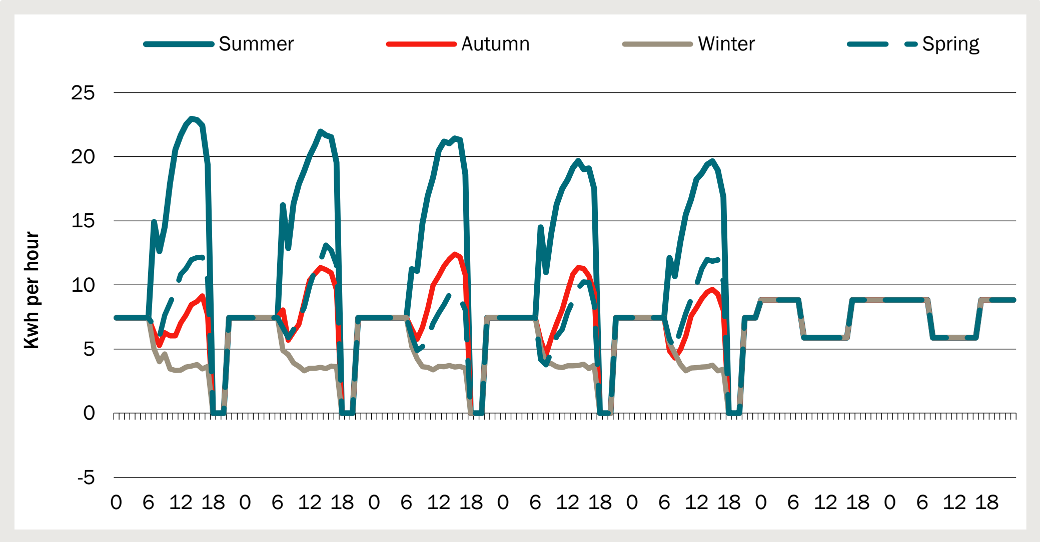
F.4 Energy savings by time of day — Stringency Level 2, large office in CZ5



Data source: DeltaQ modelling, CIE.

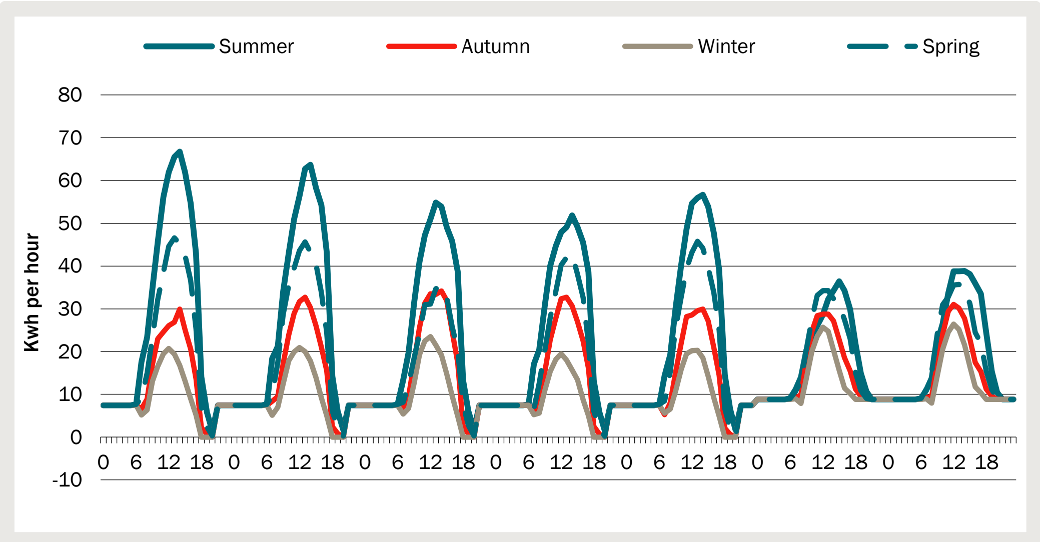
Climate zone 6

F.5 Energy savings by time of day — Stringency Level 1, large office in CZ6



Data source: DeltaQ modelling, CIE.

F.6 Energy savings by time of day — Stringency Level 2, large office in CZ6



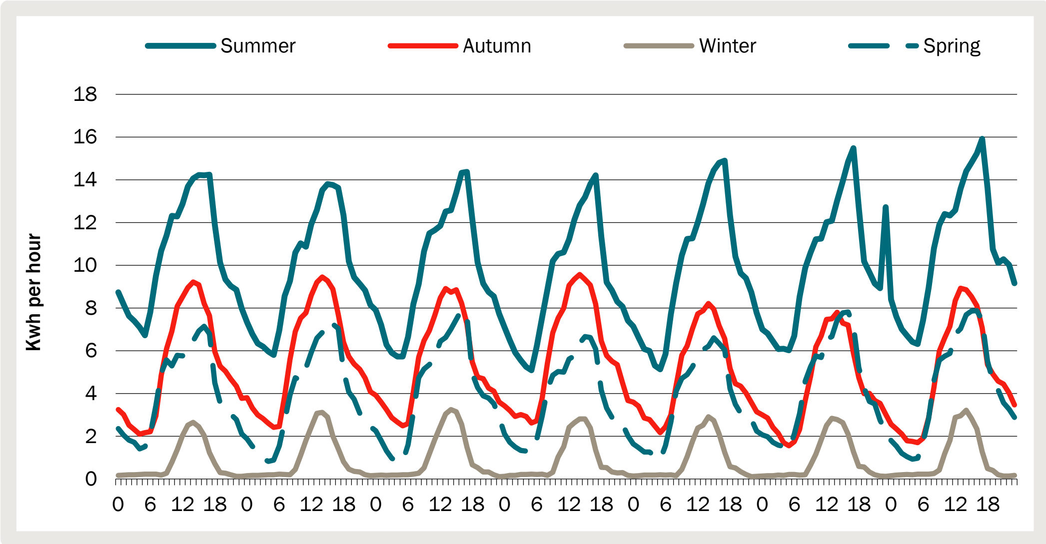
Data source: DeltaQ modelling, CIE.

Large hospital ward

Energy savings by time of day for the large hospital ward archetype (C9A) in each climate zone for Stringency Level 1 and Stringency Level 2 are shown in the charts below.

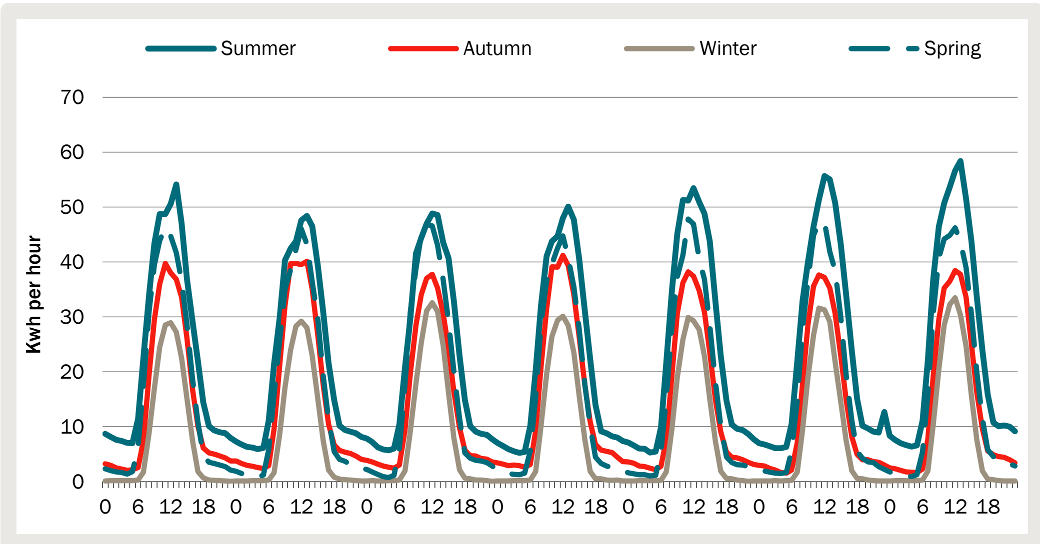
Climate zone 2

F.7 Energy savings by time of day — Stringency Level 1, large hospital ward in CZ2



Data source: DeltaQ modelling, CIE.

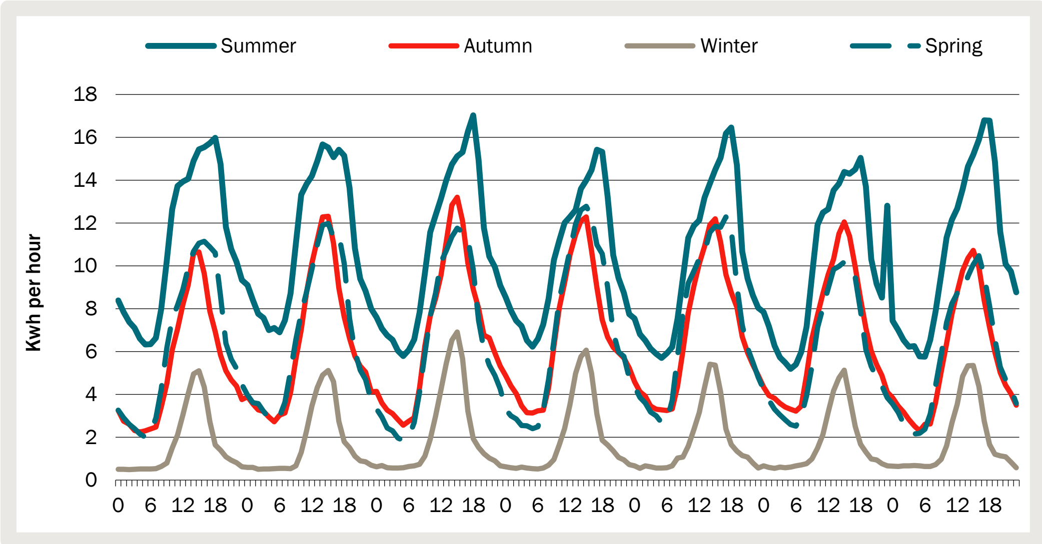
F.8 Energy savings by time of day — Stringency Level 2, large hospital ward in CZ2



Data source: DeltaQ modelling, CIE.

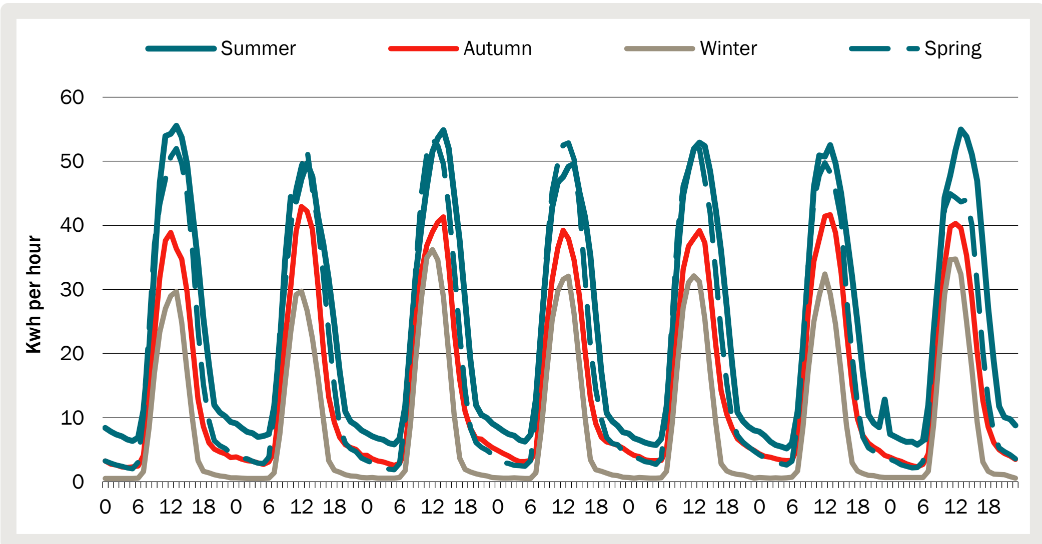
Climate zone 5

F.9 Energy savings by time of day — Stringency Level 1, large hospital ward in CZ5



Data source: DeltaQ modelling, CIE.

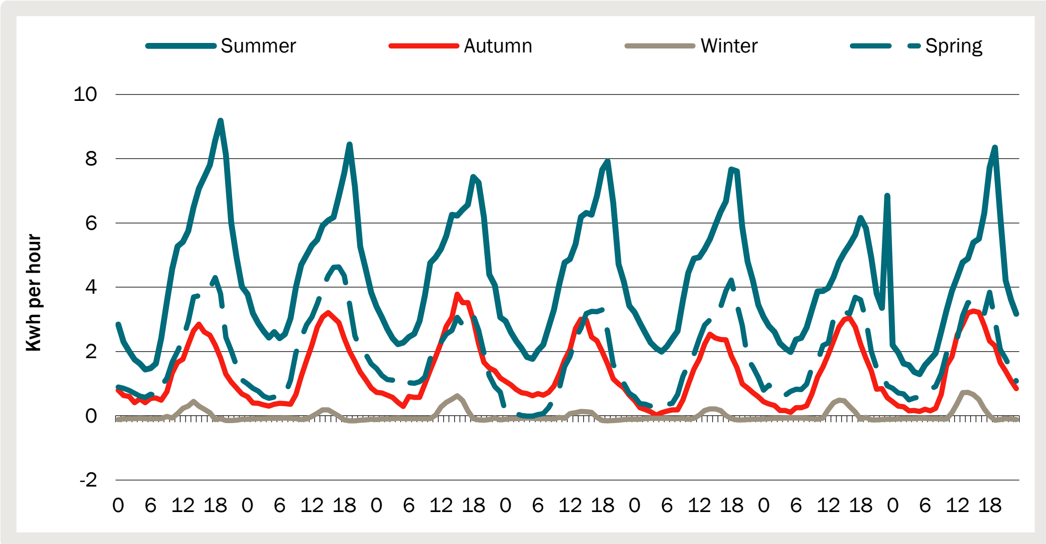
F.10 Energy savings by time of day — Stringency Level 2, large hospital ward in CZ5



Data source: DeltaQ modelling, CIE.

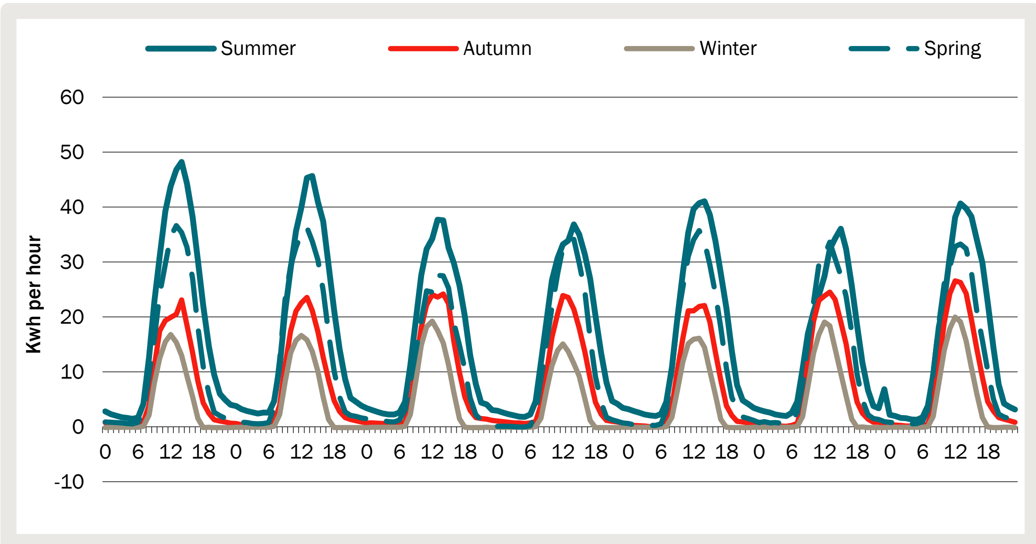
Climate zone 6

F.11 Energy savings by time of day — Stringency Level 1, large hospital ward in CZ6



Data source: DeltaQ modelling, CIE.

F.12 Energy savings by time of day — Stringency Level 2, large hospital ward in CZ6



Data source: DeltaQ modelling, CIE.

G Building-level costs and benefits

Stringency Level 1

The Stringency Level 1 building-level CBA results for each building archetype (except C5OL which is reported in the main body of the report) are reported in tables G.1 to G.9.

G.1 Stringency Level 1 estimated costs and benefits — C3HS

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	9.23	1.77	32.48	1.97	5.32	17.73	8.61	22.14
Avoided electricity wholesale costs	23.55	13.79	66.32	14.58	22.96	20.97	23.11	66.98
Avoided electricity network usage costs	9.52	9.14	32.48	26.06	23.21	7.20	11.28	22.32
Avoided electricity retail costs	6.34	3.71	19.69	6.39	7.72	6.89	6.45	16.72
Electricity exported to grid	1.08	0.36	3.56	1.02	1.40	1.36	0.98	3.68
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	11.91	19.21	69.75	21.51	8.10	2.47	10.06	67.34
Avoided GHG emissions – exported electricity	0.98	1.95	5.92	1.78	0.67	0.18	0.73	4.20
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	51.63	33.08	39.76	51.63	51.63	27.47	27.47	82.17
Total	**114.25**	**83.01**	**269.96**	**124.93**	**121.01**	**84.26**	**88.69**	**285.56**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.2 Stringency Level 1 estimated costs and benefits — C3HL

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	7.46	0.70	9.02	1.60	4.71	8.37	4.28	11.03
Avoided electricity wholesale costs	13.83	8.65	18.21	8.21	13.07	8.94	10.04	26.09
Avoided electricity network usage costs	5.70	6.07	9.89	15.00	13.52	3.57	5.59	8.37
Avoided electricity retail costs	4.05	2.31	5.57	3.72	4.69	3.13	2.99	6.82

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Electricity exported to grid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided gas costs	-2.21	-5.14	-0.93	-2.29	-2.38	-7.44	-5.21	0.00
Avoided GHG emissions – electricity	6.83	12.15	21.26	12.34	4.65	1.16	4.74	25.25
Avoided GHG emissions – exported electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – gas	-4.61	-8.69	-2.23	-4.44	-3.97	-9.34	-10.82	0.00
Capital costs	29.37	21.92	39.00	29.37	29.37	28.21	28.21	46.77
Total	**60.43**	**37.98**	**99.81**	**63.52**	**63.66**	**36.61**	**39.81**	**124.34**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.3 Stringency Level 1 estimated costs and benefits — C5OS

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	13.87	5.68	5.38	3.05	7.88	35.72	15.27	32.03
Avoided electricity wholesale costs	16.22	14.44	10.05	8.73	12.90	15.23	16.14	41.27
Avoided electricity network usage costs	8.10	12.68	5.85	19.83	18.04	5.97	10.48	13.29
Avoided electricity retail costs	5.73	4.92	3.19	4.74	5.82	8.54	6.28	12.99
Electricity exported to grid	0.72	0.31	0.46	0.57	1.01	1.36	0.87	0.53
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	8.40	21.16	13.16	15.16	5.71	1.75	7.14	40.08
Avoided GHG emissions – exported electricity	0.71	2.50	1.02	1.29	0.48	0.20	0.83	0.61
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	11.32	22.91	17.52	11.32	11.32	1.59	1.59	10.47
Total	**65.08**	**84.59**	**56.63**	**64.69**	**63.17**	**70.36**	**58.61**	**151.26**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.4 Stringency Level 1 estimated costs and benefits — C5OM

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	13.15	6.61	16.05	2.92	6.21	22.56	10.72	28.90
Avoided electricity wholesale costs	23.16	16.82	25.33	12.15	17.98	15.34	16.54	52.22

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network usage costs	12.10	16.54	15.27	29.14	26.12	6.78	12.07	16.85
Avoided retail costs	7.26	5.99	8.50	6.63	7.55	6.70	5.90	14.69
Electricity exported to grid	0.71	0.31	0.70	0.55	1.01	1.52	0.95	0.45
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	11.81	25.01	34.35	21.32	8.03	1.93	7.87	50.83
Avoided GHG emissions – exported electricity	0.71	2.71	1.52	1.28	0.48	0.23	0.95	0.52
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	6.79	-5.56	-0.36	6.79	6.79	3.11	3.11	-3.67
Total	**75.68**	**68.43**	**101.36**	**80.77**	**74.17**	**58.16**	**58.11**	**160.79**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.5 Stringency Level 1 estimated costs and benefits — C6RS

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	47.57	21.67	53.00	10.40	24.36	71.70	33.43	90.46
Avoided electricity wholesale costs	93.80	62.96	107.97	50.39	69.85	61.40	66.91	222.45
Avoided electricity network usage costs	43.25	54.05	69.01	110.34	103.19	25.50	42.11	72.38
Avoided electricity retail costs	27.69	20.80	34.50	25.67	29.61	23.79	21.37	57.79
Electricity exported to grid	1.66	0.78	1.31	1.34	2.58	3.43	2.05	0.30
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	49.24	96.50	156.66	88.91	33.50	7.84	31.99	218.34
Avoided GHG emissions – exported electricity	1.81	7.01	3.61	3.27	1.23	0.53	2.17	0.35
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	9.38	-16.25	4.16	9.38	9.38	-21.21	-21.21	18.90
Total	**274.41**	**247.53**	**430.22**	**299.69**	**273.70**	**172.99**	**178.83**	**680.97**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.6 Stringency Level 1 estimated costs and benefits — C6RL

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	33.25	7.87	37.15	7.38	19.69	80.11	38.34	55.15
Avoided electricity wholesale costs	69.25	33.93	85.44	37.51	54.05	69.19	73.09	157.81
Avoided electricity network usage costs	30.33	24.59	54.13	78.81	74.80	27.23	45.20	51.96
Avoided electricity retail costs	19.93	9.96	26.51	18.55	22.28	26.48	23.49	39.74
Electricity exported to grid	0.70	0.21	0.59	0.58	1.01	1.44	0.85	0.04
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	36.12	51.21	122.40	65.21	24.57	8.35	34.08	156.75
Avoided GHG emissions – exported electricity	0.71	1.45	1.65	1.29	0.48	0.22	0.90	0.04
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-3.08	-52.77	7.96	-3.08	-3.08	-46.60	-46.60	-54.25
Total	**187.21**	**76.45**	**335.83**	**206.24**	**193.82**	**166.42**	**169.34**	**407.24**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.7 Stringency Level 1 estimated costs and benefits — C9A

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	3.91	1.35	2.76	0.84	2.36	3.78	1.70	10.26
Avoided electricity wholesale costs	7.80	2.48	6.06	4.75	6.76	2.38	2.72	29.19
Avoided electricity network usage costs	3.84	2.15	3.63	9.72	8.64	1.17	1.82	9.14
Avoided electricity retail costs	2.33	0.90	1.87	2.30	2.66	1.10	0.94	7.29
Electricity exported to grid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided gas costs	-0.57	-1.91	-0.06	-0.60	-0.62	-2.17	-1.52	0.00
Avoided GHG emissions – electricity	4.17	3.63	8.03	7.53	2.84	0.34	1.39	27.58
Avoided GHG emissions – exported electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – gas	-1.20	-3.23	-0.15	-1.15	-1.03	-2.72	-3.15	0.00
Capital costs	16.05	15.77	12.65	16.05	16.05	15.55	15.55	-2.53
Total	**36.33**	**21.14**	**34.80**	**39.42**	**37.65**	**19.43**	**19.45**	**80.92**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.8 Stringency Level 1 estimated costs and benefits — C9B

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	17.10	9.96	21.30	3.55	6.65	33.80	17.25	32.16
Avoided electricity wholesale costs	15.63	10.95	19.51	8.25	11.46	14.98	14.47	39.90
Avoided electricity network usage costs	9.12	12.31	13.85	22.00	19.99	6.19	11.60	13.18
Avoided electricity retail costs	6.28	4.98	8.20	5.07	5.72	8.25	6.50	12.79
Electricity exported to grid	1.23	0.50	1.19	0.83	1.64	2.32	1.41	0.34
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	8.84	18.10	31.86	15.97	6.02	1.67	6.82	39.77
Avoided GHG emissions – exported electricity	1.15	3.79	2.40	2.08	0.78	0.34	1.38	0.39
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	14.74	8.09	31.83	14.74	14.74	6.68	6.68	13.10
Total	**74.08**	**68.69**	**130.15**	**72.49**	**66.99**	**74.22**	**66.10**	**151.63**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.9 Stringency Level 1 estimated costs and benefits — C9C

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	7.29	8.45	10.40	1.50	3.95	14.26	6.13	9.84
Avoided electricity wholesale costs	15.33	22.47	26.18	9.41	14.15	15.61	16.98	29.28
Avoided electricity network usage costs	6.81	14.70	13.66	18.01	16.00	5.59	8.77	9.49
Avoided electricity retail costs	4.41	6.84	7.54	4.34	5.11	5.32	4.78	7.29
Electricity exported to grid	2.38	1.14	4.67	2.17	3.33	2.39	1.68	7.11
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	7.96	28.35	29.52	14.37	5.41	1.84	7.50	28.62
Avoided GHG emissions – exported electricity	2.34	6.55	9.05	4.22	1.59	0.33	1.35	8.11
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	10.58	77.30	26.64	10.58	10.58	7.41	7.41	12.69
Total	**57.08**	**165.80**	**127.66**	**64.60**	**60.11**	**52.76**	**54.60**	**112.44**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Stringency Level 2

The Stringency Level 2 building-level CBA results for each building archetype (except C5OL which is reported in the main body of the report) are reported in tables G.10 to G.18.

G.10 Stringency Level 2 estimated costs and benefits — C3HS

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	12.63	7.09	34.75	2.59	7.75	22.57	11.33	32.41
Avoided electricity wholesale costs	38.17	29.36	80.50	23.29	34.55	35.49	38.45	99.23
Avoided electricity network usage costs	17.50	23.40	42.74	45.07	39.95	14.19	22.95	32.31
Avoided electricity retail costs	10.24	8.98	23.70	10.64	12.34	10.84	10.91	24.59
Electricity exported to grid	14.43	4.96	22.23	11.14	19.91	26.90	16.76	25.99
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	19.84	40.89	93.08	35.82	13.50	4.37	17.84	97.46
Avoided GHG emissions – exported electricity	14.00	38.88	43.71	25.27	9.52	3.81	15.54	29.61
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	4.43	-14.12	-7.44	4.43	4.43	-19.74	-19.74	34.97
Total	**131.23**	**139.43**	**333.27**	**158.25**	**141.94**	**98.44**	**114.04**	**376.57**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.11 Stringency Level 2 estimated costs and benefits — C3HL

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	8.09	1.39	9.62	1.74	5.17	9.28	4.90	12.81
Avoided electricity wholesale costs	16.46	10.95	20.30	9.68	14.68	11.09	12.18	30.37
Avoided electricity network usage costs	7.20	8.85	11.63	18.84	17.10	4.71	7.55	9.75
Avoided electricity retail costs	4.76	3.18	6.23	4.54	5.54	3.76	3.70	7.94
Electricity exported to grid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided gas costs	-2.21	-5.14	-0.93	-2.29	-2.38	-7.44	-5.21	0.00
Avoided GHG emissions – electricity	8.46	16.23	25.35	15.27	5.76	1.47	6.01	29.41
Avoided GHG emissions – exported electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – gas	-4.61	-8.69	-2.23	-4.44	-3.97	-9.34	-10.82	0.00
Capital costs	25.65	18.58	35.79	25.65	25.65	25.50	25.50	43.17

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Total	**63.80**	**45.34**	**105.76**	**69.00**	**67.56**	**39.04**	**43.81**	**133.46**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.12 Stringency Level 2 estimated costs and benefits — C5OS

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	21.10	12.97	12.43	4.38	12.04	49.93	22.47	44.38
Avoided electricity wholesale costs	36.10	35.13	29.40	19.80	26.20	37.09	37.93	75.36
Avoided electricity network usage costs	20.56	37.73	20.87	50.29	45.63	17.56	31.68	24.25
Avoided electricity retail costs	11.66	12.87	9.41	11.17	12.58	15.69	13.81	21.60
Electricity exported to grid	5.04	1.59	5.62	4.09	6.96	9.54	6.13	9.07
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	20.36	54.05	48.43	36.76	13.85	4.79	19.55	73.16
Avoided GHG emissions – exported electricity	4.89	14.79	12.86	8.84	3.33	1.43	5.84	10.34
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-25.75	-14.16	-19.56	-25.75	-25.75	-35.48	-35.48	-26.61
Total	**93.97**	**154.96**	**119.47**	**109.57**	**94.84**	**100.55**	**101.93**	**231.55**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.13 Stringency Level 2 estimated costs and benefits — C5OM

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	20.01	12.57	22.89	4.34	9.96	34.82	16.63	44.23
Avoided electricity wholesale costs	41.06	35.37	42.41	22.11	29.89	35.10	36.22	82.47
Avoided electricity network usage costs	23.28	39.02	28.54	56.59	51.03	17.28	31.25	26.58
Avoided electricity retail costs	12.65	13.04	14.08	12.46	13.63	13.08	12.62	22.99
Electricity exported to grid	4.26	1.36	5.23	3.46	5.89	8.22	5.27	7.82
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	22.62	54.61	65.50	40.83	15.39	4.69	19.13	80.19
Avoided GHG emissions – exported electricity	4.14	12.97	11.92	7.48	2.82	1.24	5.06	8.91

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-23.66	-36.02	-30.81	-23.66	-23.66	-27.34	-27.34	-34.12
Total	**104.36**	**132.92**	**159.77**	**123.61**	**104.93**	**87.08**	**98.83**	**239.08**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.14 Stringency Level 2 estimated costs and benefits — C6RS

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	68.12	39.60	71.36	14.36	34.08	95.41	45.09	134.28
Avoided electricity wholesale costs	146.97	113.22	158.11	80.07	102.86	119.27	125.02	336.48
Avoided electricity network usage costs	73.34	112.63	110.16	187.20	174.74	55.68	93.80	109.10
Avoided retail costs	43.26	39.82	50.94	42.24	46.75	40.55	39.59	86.98
Electricity exported to grid	3.47	1.87	2.63	2.84	5.38	8.85	5.29	0.60
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	81.76	182.70	253.69	147.61	55.62	16.07	65.57	329.13
Avoided GHG emissions – exported electricity	3.78	17.31	7.21	6.83	2.57	1.42	5.81	0.68
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-66.02	-91.65	-71.25	-66.02	-66.02	-96.61	-96.61	-70.52
Total	**354.68**	**415.49**	**582.86**	**415.13**	**355.98**	**240.64**	**283.54**	**926.73**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.15 Stringency Level 2 estimated costs and benefits — C6RL

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	48.84	22.44	50.81	10.31	27.73	96.99	46.51	89.79
Avoided electricity wholesale costs	114.99	77.67	128.06	63.01	82.18	120.00	123.91	236.87
Avoided electricity network usage costs	56.31	76.54	89.30	145.31	136.79	54.04	91.17	77.43
Avoided electricity retail costs	33.02	26.50	40.23	32.79	37.01	40.65	39.24	60.61
Electricity exported to grid	1.51	0.73	1.19	1.28	2.23	3.66	2.20	0.07
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	64.26	127.48	205.35	116.01	43.71	15.66	63.88	233.59

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided GHG emissions – exported electricity	1.57	6.31	3.31	2.84	1.07	0.58	2.38	0.08
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-67.63	-117.31	-56.59	-67.63	-67.63	-111.15	-111.15	-118.80
Total	**252.87**	**220.36**	**461.66**	**303.92**	**263.10**	**220.43**	**258.15**	**579.66**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.16 Stringency Level 2 estimated costs and benefits — C9A

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	4.94	2.52	3.70	1.02	2.91	4.91	2.97	11.72
Avoided electricity wholesale costs	12.12	5.83	9.32	7.16	9.41	6.28	6.62	35.27
Avoided electricity network usage costs	6.31	6.20	6.34	16.03	14.53	3.25	5.39	11.10
Avoided electricity retail costs	3.51	2.18	2.90	3.63	4.03	2.17	2.25	8.71
Electricity exported to grid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided gas costs	-0.57	-1.91	-0.06	-0.60	-0.62	-2.17	-1.52	0.00
Avoided GHG emissions – electricity	6.84	9.58	14.42	12.35	4.65	0.91	3.70	33.50
Avoided GHG emissions – exported electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – gas	-1.20	-3.23	-0.15	-1.15	-1.03	-2.72	-3.15	0.00
Capital costs	10.23	11.03	7.78	10.23	10.23	10.78	10.78	-7.49
Total	**42.17**	**32.21**	**44.26**	**48.68**	**44.11**	**23.40**	**27.04**	**92.82**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.17 Stringency Level 2 estimated costs and benefits — C9B

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	27.71	17.75	31.41	5.74	11.06	47.03	26.04	56.27
Avoided electricity wholesale costs	30.95	25.35	35.70	16.65	21.54	31.72	30.83	68.83
Avoided electricity network usage costs	19.22	31.34	26.50	46.51	42.17	15.06	28.45	22.59
Avoided electricity retail costs	11.68	11.17	14.04	10.33	11.22	14.07	12.80	22.15

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Electricity exported to grid	7.83	3.08	8.56	6.40	10.10	14.52	9.44	11.23
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	18.27	41.93	61.61	32.98	12.43	3.96	16.18	68.14
Avoided GHG emissions – exported electricity	7.10	22.98	17.52	12.83	4.83	2.11	8.62	12.79
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-17.65	-24.30	-0.56	-17.65	-17.65	-25.71	-25.71	-19.29
Total	**105.11**	**129.29**	**194.77**	**113.77**	**95.70**	**102.76**	**106.64**	**242.70**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.18 Stringency Level 2 estimated costs and benefits — C9C

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	9.38	13.65	11.51	1.88	5.36	17.64	8.26	13.85
Avoided electricity wholesale costs	31.45	38.28	41.86	18.65	25.72	33.05	34.73	73.72
Avoided electricity network usage costs	15.75	31.18	25.37	40.05	36.09	14.22	23.35	23.32
Avoided electricity retail costs	8.49	12.47	11.81	9.09	10.08	9.74	9.95	16.63
Electricity exported to grid	9.67	3.81	14.40	7.72	13.59	16.00	10.15	37.33
Avoided gas costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions – electricity	17.21	52.93	56.72	31.08	11.71	4.19	17.09	70.35
Avoided GHG emissions – exported electricity	9.56	28.06	29.92	17.25	6.50	2.33	9.52	42.54
Avoided GHG emissions – gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital costs	-24.38	42.34	-8.32	-24.38	-24.38	-27.55	-27.55	-45.41
Total	**77.12**	**222.73**	**183.27**	**101.33**	**84.67**	**69.62**	**85.53**	**232.35**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

Stringency Level 3

The Stringency Level 3 building-level CBA results for building archetypes C3HL and C9A are reported in tables G.19 and G.20. The results for building archetype C5OL are reported in the main body of the report. As the remaining building archetypes are modelled as fully electric, Stringency Level 3 is not relevant to those archetypes.

G.19 Stringency Level 3 estimated costs and benefits — C3HL

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	5.50	1.59	8.00	1.23	5.28	-9.27	-4.19	14.16
Avoided electricity wholesale costs	7.36	4.41	17.50	5.92	6.16	-7.92	-9.03	33.61
Avoided electricity network usage costs	5.22	6.85	10.51	13.25	11.28	-0.68	-1.08	10.79
Avoided electricity retail costs	2.71	1.93	5.40	3.06	3.41	-2.68	-2.14	8.78
Electricity exported to grid	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Avoided gas costs	2.20	8.62	0.59	2.28	2.37	26.74	18.73	0.00
Avoided GHG emissions - electricity	5.37	10.07	22.93	9.70	3.65	-0.47	-1.92	32.54
Avoided GHG emissions - exported electricity	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Avoided GHG emissions - gas	4.59	14.58	1.41	4.42	3.95	33.58	38.90	0.00
Capital costs	-16.24	-13.97	-6.46	-16.24	-16.24	-2.13	-2.13	1.47
Total	**16.72**	**34.31**	**59.90**	**23.63**	**19.87**	**37.16**	**37.13**	**101.36**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

G.20 Stringency Level 3 estimated costs and benefits — C9A

Impact	NSW (CZ5) $ per m2	VIC (CZ6) $ per m2	QLD (CZ2) $ per m2	WA (CZ5) $ per m2	SA (CZ5) $ per m2	TAS (CZ7) $ per m2	ACT (CZ7) $ per m2	NT (CZ1) $ per m2
Avoided electricity network capacity costs	4.72	3.37	2.83	0.96	2.91	-5.54	-2.18	12.39
Avoided electricity wholesale costs	10.94	5.24	7.54	6.68	8.09	-2.04	-2.38	39.53
Avoided electricity network usage costs	6.20	7.34	5.75	15.65	14.06	0.95	1.65	12.47
Avoided electricity retail costs	3.28	2.39	2.42	3.49	3.76	-1.00	-0.44	9.66
Electricity exported to grid	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Avoided gas costs	0.21	2.12	0.84	0.22	0.23	11.51	8.06	0.00
Avoided GHG emissions - electricity	6.55	10.24	13.18	11.83	4.46	0.08	0.32	37.61
Avoided GHG emissions - exported electricity	0.00	0.16	0.00	0.01	0.00	0.00	0.00	0.00
Avoided GHG emissions - gas	0.44	3.59	2.01	0.43	0.38	14.46	16.75	0.00
Capital costs	-46.95	-27.37	-51.01	-46.95	-46.95	-19.77	-19.77	-47.49
Total	**-14.59**	**7.09**	**-16.44**	**-7.68**	**-13.05**	**-1.35**	**2.02**	**64.16**

Note: Costs and benefits estimated in present value terms over the 50-year life of a building constructed in 2025, using a discount rate of 5 per cent.

Source: CIE based on DeltaQ modelling.

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