ACIL ALLEN

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Report to Australian Building Codes Board

National Construction Code 2022

Decision Regulation Impact Statement for a proposal to increase residential building energy efficiency requirements

About ACIL Allen

ACIL Allen is a leading independent economics, policy and strategy advisory firm, dedicated to helping clients solve complex issues.

Our purpose is to help clients make informed decisions about complex economic and public policy issues.

Our vision is to be Australia's most trusted economics, policy and strategy advisory firm. We are committed and passionate about providing rigorous independent advice that contributes to a better world.

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Glossary

AAOs	Assessor Accrediting Organisations
ABCB	Australian Building Codes Board
ACCU	Australian Carbon Credit Unit
ACOP	Annualised Coefficient of Performance
ACOSS	Australian Council of Social Service
ACT	Australian Capital Territory
AEER	Annualised Energy Efficiency Ratio
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGWA	Australian Glass and Window Association
AIRAH	Australian Institute of Refrigeration, Air conditioning and Heating
ASBEC	Australian Sustainable Built Environment Council
ATSE	Australian Academy of Technological Sciences and Engineering
BAU	Business as usual
BASIX	Building Sustainability Index
BCA	Building Code of Australia
BCC	Building Codes Committee
BCR	Benefit Cost Ratio
BMF	Building Ministers' Forum
CBA	Cost Benefit Analysis
CBD	Commercial Building Disclosure

COAG	Council of Australian Governments
CPD	Continuing Professional Development
CPI	Consumer Price Index
CRIS	Consultation Regulation Impact Statement
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CZ	Climate Zone
DCCEE	Department of Climate Change and Energy Efficiency
DCF	Discounted cash flow
DELWP	Department of Environment, Land, Water and Planning (Victoria)
DISER	Department of Industry, Science, Energy and Resources
DRIS	Decision Regulation Impact Statement
DTS	Deemed-to-Satisfy
E3	Equipment Energy Efficiency
EEC	Energy Efficiency Council
EES	Energy Efficiency Strategies
ENA	Energy Networks Australia
EPS	Expanded polystyrene
ESOO	Electricity Statement of Opportunities
EVs	Electric Vehicles
GEMS	Greenhouse and Energy Minimum Standards
GBCA	Green Building Council of Australia
GWh	Gigawatt hours
HIA	Housing Industry Association
HSPF	Heating Seasonal Performance Factor
IGA	Inter-Governmental Agreement
ISP	Integrated System Plan

kWh	KiloWatt-hour
LCA	Lighting Council Australia
LCOE	Levelised Cost of Electricity
LGC	Large-scale Generation Certificate
LRET	Large-scale Renewable Energy Target
LRMC	Long run marginal cost
LVR	Loan to value ratio
MLF	Marginal Loss Factors
MEPS	Minimum Energy Performance Standards
MJ	Megajoules
MW	MegaWatt
MWh	Megawatt hour
NABERS	National Australian Built Environment Rating System
NatHERS	Nationwide House Energy Rating Scheme
NASH	National Association of Steel Framed Housing
NCC	National Construction Code
NEM	National Electricity Market
NEPP	National Energy Productivity Plan
NER	National Electricity Rules
NPV	Net Present Value
NSW	New South Wales
NT	Northern Territory
OBPR	Office of Best Practice Regulation
O&M	Operating and maintenance
OLA	Outdoor Living Area
PCA	Property Council of Australia

PCD	Public Comment Draft
PFC	Proposal for Change
PJ	Petajoules
PV	Photovoltaics
PVa	Present Value
QLD	Queensland
QRET	Queensland Renewable Energy Target
REES	Retailer Energy Efficiency Scheme
REZ	Renewable Energy Zones
RIA	Regulatory Impact Analysis
RIS	Regulation Impact Statement
SA	South Australia
SCA	Strata Community Association
SCC	Social Cost of Carbon
SIPS	System Integrity Protection Scheme
SOU	Sole occupancy unit
SRMG	Short Run Marginal Cost
SSREM	Small Scale Renewable Energy Model
STC	Small-scale technology certificate
TAS	Tasmania
TCSPF	Total Cooling Seasonal Performance Factor
TIC	Tony Isaacs Consulting
TRET	Tasmania Renewable Energy Target
VIC	Victoria
VNI	Victoria-New South Wales interconnector
VM	Verification methods

VREAS	Victorian Renewable Energy Auction Scheme
VRET	Victorian Renewable Energy Target
VURB	Verification using a reference building
WA	Western Australia
WACC	Weighted Average Cost of Capital
WEM	Western Australian Electricity Market
WoH	Whole-of-Home

Disclaimer

The Australian Building Codes Board (ABCB) has commissioned ACIL Allen to prepare this Consultation Regulation Impact Statement (RIS) in accordance with the requirements of the *Guide for Ministerial Councils and National Standard Setting Bodies*. This Decision RIS (DRIS) incorporates relevant information and data gathered through consultation, and updates as a result of ongoing work on the technical proposals. The report will be used by the ABCB as an input into its final decision making. The views expressed in this report are those of the authors and should not be construed as having been endorsed by, or as representing the final views of, the ABCB.

Executive summary

The Australian Building Codes Board (ABCB) has been asked by the former Building Ministers' Forum (BMF) to update the energy efficiency provisions for new residential buildings in the 2022 edition of the National Construction Code (NCC), informed by the former COAG Energy Council's Trajectory for Low Energy Buildings (the Trajectory).

As part of the NCC 2022 development process, the ABCB engaged ACIL Allen to develop a Regulation Impact Statement (RIS) assessing the costs and benefits of proposed increases in energy efficiency requirements in the NCC 2022 for new residential buildings.

As a first stage in the RIS process, we developed a Consultation RIS (CRIS) assessing two policy options to increase the energy efficiency requirements in the NCC, for the purpose of consulting with interested stakeholders. The analysis in the CRIS indicated (based on the best available data and assumptions at that time) that there would be a net societal cost for both options analysed – the costs were estimated to outweigh the benefits by a significant margin.

The CRIS was published for public comment from 20 September 2021 until 7 November 2021 through the ABCB's Consultation Hub platform.[1] Consultation focused around 38 structured questions to assist the public to provide feedback. There were a total of 110 responses from stakeholders on the CRIS. These responses were received from a wide range of stakeholders, including industry associations, not-for-profit organisations, state governments, local councils, political parties, and product manufacturers and professionals associated with the building industry.

This Decision RIS (DRIS) incorporates relevant information and data gathered through the consultation process, and updates as a result of ongoing work on the technical proposals (refer to Table ES.1 for a summary of the key changes to the analysis since the CRIS was released). The DRIS has been developed in accordance with the best practice regulatory principles administered by the Office of Best Practice Regulation (OBPR) and set out in the Regulatory Impact Analysis Guide For Ministers' Meetings And National Standard Setting Bodies.[2] This report will be used by the ABCB as an input into its final decision making.

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[1] Feedback to the questions asked during consultation can be viewed at https://consultation.abcb.gov.au/engagement/consultation-ris-proposed-ncc-2022-residential/

[2] Commonwealth of Australia, Department of the Prime Minister and Cabinet 2021, *Regulatory Impact Analysis Guide for Ministers' Meetings and National Standard Setting Bodies*, May.

The residential buildings covered in this RIS analysis are new Class 1 and Class 2 sole occupancy units (SOUs).[3] Notably, the economic analysis in this RIS has been undertaken assuming that the proposed changes to the NCC start in 2022. However, in practice, it is anticipated that the regulations would start in the second half of the year and will likely have a transition period. As discussed later in the RIS, a transition period for the introduction of the proposed standards is likely to reduce the costs of the regulation.

Table ES 1 What has changed since the CRIS?

Change	Impact on the analysis [a]
Changes to the technical modelling underpinning the cost benefit analysis	
Optimisation of expected design solution — a revised design optimisation process was developed by the ABCB's technical consultants that considered a much broader range of cost effective compliance options, which resulted in significantly improved results (particularly for Class 2 dwellings).	H
Factoring in the **impact of the outdoor living area** (OLA) provisions of NCC 2019 — these provisions were not factored into the technical modelling underpinning the CRIS. The inclusion of these provisions has reduced the cost of compliance for those dwellings that include an OLA (Class 1 dwellings in NCC climate zones 1 and 2 in Queensland, the Northern Territory and Western Australia[4]).	L
Factoring in the impact of the **NCC 2022 elemental provisions** — the newly refined elemental provisions are expected to lower costs in 2022 for the 20 per cent of Class 1 dwellings (nationally) that use the elemental provisions.[b] These savings have now been factored into the technical analysis.	M
Amendments to the assumed propensity of **gas heating in Victoria in the baseline** — the assumed propensity of gas heating in new Victorian houses under the baseline was amended (increased) to better align with estimates provided by the Victorian Government.	L
Amendments to the assumed level of **STC credits for PVs** — the technical modelling was changed to reflect annual, rather than average, credits.	L
Adjustments to the assumed **propensity and capacity of PVs** installed into Class 1 dwellings under the base case (based on additional C4NET analysis).	L

[3] Notably, a Class 4 part of a building would also be affected by the proposed changes for Class 2 sole-occupancy units, but they are not included in this analysis due to their infrequent construction.

[4] The OLA concession does not apply in NSW.

Change	Impact on the analysis [a]
Changes to the cost benefit analysis	
The **compliance costs and energy flows** associated with the proposed policy options have been updated based on the updated technical modelling.	H
The benefits of the provisions to address **thermal bridging** in steel framed buildings have been included in the analysis (in addition to their cost).	M
The revised analysis incorporates the **amenity benefits** associated with the rebound effect.	M
A **learning rate** for glazing has been introduced in the analysis.	L
The **value of greenhouse gas (GHG) emissions** savings is now based on estimates of the Social Cost of Carbon (SCC) and updated emission intensity factors recently released by the Department of Industry, Science, Energy, and Resources (DISER).	H
The **health benefits** from reductions in gas and wood use have been incorporated in the analysis.	L
The **energy prices** used in the analysis have been updated based on updated energy market modelling.	M
Industry costs have been adjusted to include redesign, transition and administrative costs.	L

[a] The level of impact can vary according to the particulars of each jurisdiction and according to the dwelling class.
[b] This relates primarily to the glazing calculator.
Note: L = low impact; M= medium impact; H= high impact.
Source: ACIL Allen

Statement of the problem

Residential buildings are a major source of energy demand and use. They currently account for approximately 7.9 per cent of Australia's energy use (across all fuels)[5], around 29 per cent of electricity use and are responsible for around 11 per cent of Australia's GHG emissions[6]. Since 1974, residential energy use has increased by an average rate of 1.6 per cent per year faster than the rate of population growth, which was 1.3 per cent over the same period. This represents more

[5] Department of Industry, Science, Energy and Resources 2021, *Australian Energy Statistics*, Table E, September.

[6] COAG Energy Council 2019, Report for Achieving Low Energy Existing Homes, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20Report%20for%20Achieving%20Low%20Energy%20Existing%20Homes_1.pdf, accessed 28 September 2020.

than a 100 per cent increase in residential sector energy consumption over the period from 1973-74 to 2019-20.

While Australia has made considerable progress in the energy performance of residential buildings, there is still opportunity to implement actions that could further reduce the energy consumption of the sector. Indeed, the National Energy Productivity Plan (NEPP) identified that residential buildings can contribute significantly to reach the target of improving Australia's energy productivity by 40 per cent between 2015 and 2030 by reducing Australia's energy use by 84 PJ.

There are a number of market failures that inhibit socially optimal energy efficiency decisions, and result in over consumption of energy and underinvestment in energy efficiency. These may include:

— **unpriced negative effects** (externalities) associated with energy consumption which result in energy prices that do not fully reflect the cost of consuming energy (which includes the cost of GHG emissions and externalities associated with peak demand)
— **information problems**, where households do not have perfect information about available energy efficiency opportunities and transactions that are cost effective and hence these opportunities are not taken, resulting in economically inefficient outcomes
— **split incentives**, where the parties engaged in a contract for a new building have different goals, and different levels of information and incentives. In the context of new buildings, this relates to builders or designers who may make decisions about the energy efficiency features of a new dwelling, but energy costs are paid solely by the buyers (or tenants) of these dwellings. This may result in underinvestment in cost effective energy efficiency measures.

Commonwealth, state, and territory governments have introduced a number of measures to address these market failures, reduce energy use and improve the energy efficiency of the residential sector, including the minimum energy efficiency requirements for new residential buildings in the NCC (which have been in place since 2003 for houses and since 2005 for multi-residential buildings). However, in principle, there is a case for a further increase in the minimum energy efficiency requirements in the NCC for residential buildings on the basis of:

— recent policy commitments and directions, including:
  – all Australian state and territory governments are committed to net zero emissions by 2050 or earlier
  – the NEPP, which sets a target of improving Australia's energy productivity by 40 per cent by 2030 on 2015 levels and includes a number of measures to reduce the energy use of residential buildings. Specifically, Measure 31 of the NEPP recommends the consideration of changes to the NCC to achieve better energy efficiency outcomes for Australia's buildings
  – the Trajectory, which sets a plan towards zero energy (and carbon) ready buildings for Australia and identifies opportunities for the building sector. The Trajectory suggests a number of changes to increase the stringency of energy efficiency provisions in the NCC for residential buildings
— while there has been significant change in residential energy efficiency over the last 10 years (including the introduction of heating and cooling load limits) the current minimum thermal fabric requirements in the NCC have remained at the current Nationwide House Energy Rating

Scheme (NatHERS) 6-star level. As noted by the former COAG Energy Council, it is important to consider updating the requirements to 'reflect changes in building practices, advances in building products and technology, falling costs for renewable energy, improvements in energy efficient appliances and batteries, rising energy prices, and issues that impact on energy system reliability and costs'[7]

— the existing market failures outlined above
— available evidence suggesting that there are significant opportunities to cost effectively improve the energy efficiency of new residential buildings
— the significant benefits that energy savings can provide to households, particularly to vulnerable households[8]
— the benefits to households of more energy efficient residential buildings, including improved social equity, amenity, health and wellbeing, and resilience to extreme weather events and in the event of power outages.

Objectives

The stated objective of the energy efficiency requirements in the NCC is to reduce GHG emissions. In response to an action suggested in the Trajectory, part of the proposed changes to the NCC 2022 include broadening the objectives of the energy efficiency requirements in the NCC to:

— reduce energy consumption and energy peak demand
— reduce greenhouse gas emissions
— improve occupant health and amenity.

As discussed above, the particular changes proposed to the energy efficiency requirements in the NCC for residential buildings have been driven by a number of broader policies, including commitments by governments to net zero emissions by 2050 (or earlier) and the Trajectory. The broader objectives of these policies, and of the changes suggested to the energy efficiency requirements for residential buildings, can be summarised as to:

— reduce energy costs for households and businesses
— maintain Australia's competitiveness and grow the economy
— reduce carbon emissions and improve sustainability.[9]

Notably, these objectives implicitly indicate an objective of achieving cost-effective energy efficiency improvements (i.e. changes that deliver net benefits to households and the economy).

[7] Council of Australian Governments (COAG) Energy Council 2018, *Report for Achieving Low Energy Homes*, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Report%20for%20Achieving%20Low%20Energy%20Homes.pdf, accessed 16 September 2020, p. 16.

[8] The Trajectory suggested that 'Potential NCC 2022 improvements could deliver bill savings to new home buyers and their renters of over $650 each year in colder or tropical climates, such as Canberra, Townsville and Darwin, and around $170 each year in more temperate climates, such as Sydney, Melbourne and Adelaide' (COAG Energy Council 2018*, Report for Achieving Low Energy Homes*, p.2).

[9] COAG Energy Council 2015, *National Energy Productivity Plan 2015-2030*, P. 13.

The objectives of the NCC energy efficiency provisions and the stated objectives of the NEPP are broad and, as such, there are a wide range of policy measures that can contribute towards the achievement of these objectives, including measures unrelated to residential buildings and outside the remit of the NCC and the ABCB. However, the analysis in this RIS focuses solely on policy options that relate to improving the energy efficiency of new residential buildings and are within the remit of the NCC and the ABCB.

Policy options

In July 2019 the ABCB released a scoping study titled ‘Energy efficiency: NCC 2022 and beyond’. This study invited stakeholder feedback on the ABCB’s proposed approach to the energy efficiency requirements for the 2022 edition of the NCC. After a period of public consultation, the ABCB released an outcomes report in December 2019 that summarised the information received during the consultation period.

The insights gathered through the consultation period on the scoping study were used to inform and refine the scope of proposed changes to the energy efficiency provisions for NCC 2022. In particular, Option 2 in the scoping study forms the basis for the two policy options analysed in this RIS.

Following the scoping study, the ABCB, through the engagement of consultants, developed the technical provisions that form part of the NCC 2022 proposal. In developing these provisions, the ABCB consulted regularly with a technical working group (consisting of industry and government stakeholders) who provided feedback and guided the development of these technical provisions.

Feedback on the provisions has also been provided by the ABCB’s peak technical committee, the Building Codes Committee (BCC), the Board of the ABCB (which includes industry representatives) and through a formal public consultation process.

The policy options formally considered under this RIS, which are intended to apply to new Class 1 buildings, Class 2 sole-occupancy units and Class 4 parts of buildings, are the following (Option B is introduced first because it is the basis for calculating Option A):

— **The Business as Usual (BAU) or status quo** — an option where there are no changes to the energy efficiency requirements for residential buildings in the NCC 2022. The BAU provides the baseline against which the impacts of the alternative options discussed below are evaluated.

— **Option B** – this option sets a maximum annual energy use budget (based on societal cost) for the elements of a building regulated by the NCC (space conditioning, water heating systems, lighting, and pool and spa pumps). The budget is based on a ‘benchmark home’ built with the following characteristics:
  – building shell performance level: equivalent to a 7 star NatHERS rated dwelling

- heating equipment: equivalent to a 4.5 star rated (Greenhouse and Energy Minimum Standards (GEMS) 2012) heat pump heater (Annualised Energy Efficiency Ratio, AEER = 4.5) [10]
- cooling equipment: equivalent to a 4.5 star rated (GEMS 2012) heat pump cooler (Annualised Coefficient of Performance, ACOP = 4.5) [11]
- water heater: instantaneous gas
- 4 Watts per square metre of lighting.

Under this option, a societal cost of operating this benchmark building is calculated and a new building is deemed to be compliant if it has the same societal cost as the benchmark building. If a piece of equipment (e.g. water heating) is installed that performs worse than the benchmark, this will have to be offset either through installing other equipment that performs sufficiently better than the benchmark (e.g. cooling) or through the installation of on-site renewables (solar photovoltaics (PV)).

The societal costs of operating a building are the combined cost of the fuels used and the costs associated with the GHG emissions of each fuel type. Greenhouse gas emission costs are calculated by multiplying the energy use by the GHG intensity of each fuel type by a dollar value per tonne of GHG emissions (CO2-e).[12]

- **Option A** – this option is based on the same energy use budget as Option B, however, the budget is 70 per cent of the Option B benchmark (i.e. a compliant dwelling must achieve savings equivalent to 30 per cent of the societal cost of applying the equipment and building fabric performance level of the benchmark building specified in Option B). For example, if the societal cost associated with the benchmark building in Option B is $1,000 per annum, then under Option A, a societal cost of $700 must be achieved.

  Compliance can be achieved either by improving the performance of the building shell, its regulated equipment or by adding some solar PV, or a combination of these approaches.

No change is proposed to the existing lighting provisions in the NCC under any of the policy options.

Notably, the two proposed options will enable a ‘whole-of-house’ (WoH) approach to achieve compliance. This means that a dwelling’s annual energy use can be achieved within an energy budget allowing, through the NatHERS or Performance Solution pathways, a trade-off between the performance of individual building elements, but only once a minimum level of thermal comfort has been reached. That is, you cannot reduce the effectiveness of the thermal shell below a 7 star NatHERS rated performance, or equivalent.[13]

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[10] Under the latest 2019 GEMS determination, in terms of seasonal ratings, this would equate to 3 Stars i.e. a Heating Seasonal Performance Factor (HSPF) of 4.5.

[11] Under the latest 2019 GEMS determination, in terms of seasonal ratings, this would equate to 3 Stars i.e. a Total Cooling Seasonal Performance Factor (TCSPF) of 4.5.

[12] For further details about how the societal cost of energy is defined, please refer to the ABCB Scoping Study (https://consultation.abcb.gov.au/engagement/energy-efficiency-scoping-study-2019/).

[13] Trading between the thermal shell and appliances will not be possible when using the DTS elemental compliance pathway.

The existing pathways for demonstrating compliance with the NCC will remain, including combinations of:

- the Deemed-to-Satisfy (DTS) elemental provisions
- DTS NatHERS provisions
- verification using a reference building (VURB)
- Performance Solutions.

These pathways can be used to demonstrate compliance, offering flexibility in achieving the objective for design.

Notably, following the release of the CRIS, the ABCB investigated alternative regulatory options that had the potential to achieve increased energy efficiency with a greater benefit cost ratio (BCR) than the options explored in the CRIS. However, after further investigation of these options, the ABCB decided to keep the policy options unchanged. A summary of these alternative options and the rationale for not pursuing them further is provided in Table ES 2. A more detailed discussion about these alternative policy options is provided in Section 4.2.

Table ES 2 Alternative policy options assessed after the CRIS

Option description	Rationale for not pursuing further
Lower stringency benchmark for WoH This option would entail lowering the benchmark to 3 star (2012 GEMS) heating and cooling equipment, which would have the effect of lowering the stringency of the proposal.	This option had the potential of lowering capital costs to upgrade to less efficient equipment. However, initial analysis showed that the indicative improvements to the BCR for this option were small. Given that this proposal did not improve outcomes relative to the existing options, and was less stringent, it was not analysed in-depth or pursued any further.
Lower stringency thermal fabric provisions in northern climates This option entailed lowering the proposed minimum building fabric rating to 6.5 stars in climate zones 1 to 3 (and retaining 7-stars for all other climate zones).	Tests on this option showed that, on average, reductions in cost were lower than the reductions in energy load, which would have resulted in an improvement in the BCRs of the affected climate zones (and an increase in the national average). However, due to other changes made to the central proposal that improved the national BCR (outlined in Table ES 1), this option was not analysed in-depth or pursued any further.
WoH only This proposal would entail maintaining the minimum efficiency of the building fabric at 6 stars and setting the WoH budget so that the energy savings were equivalent to Option A (which assumes a 7-star thermal shell). This scenario requires on balance more efficient heating and cooling equipment or more PV to achieve the budget. This option would achieve the same level of energy savings as the options proposed in the CRIS, but with flexibility to do so at the lowest cost as the cost of increasing efficiency of equipment or adding PV is less costly than increasing the performance of the fabric.	Initial analysis indicated that this option would have significantly increased the BCR of the proposal through both lower costs and greater benefits from higher PV uptake. However, due to other changes made to the central proposal that improved the national BCR (outlined in Table ES 1), this option was not analysed in-depth or pursued any further.
Removal of lighting provisions from energy efficiency provisions	The ABCB reviewed its policy position in recognition of the Lighting Council of Australia’s feedback and considered that the arguments and evidence provided were not sufficient to diverge from the policy direction set by the Trajectory

Source: ABCB.

Non-regulatory options

The Guidelines for Regulatory Impact Assessment require that a RIS identifies a range of viable options including, as appropriate, non-regulatory, self-regulatory and co-regulatory options.[14] However, this RIS does not quantitatively assess these approaches to achieve the objectives of government action. This approach recognises that:

— there are a range of non-regulatory measures already in place to encourage increased energy efficiency of residential buildings at both the national and state/territory level, and many other options are being considered as part of the NEPP
— it has been acknowledged (through the NEPP, the Trajectory and other policies) that, to address the diversity of market barriers that exist, a suite of policies and tools are needed to drive increased energy efficiency in buildings (including regulation)
— the need for regulation in this space has been established in the past, with various regulations relating to energy efficiency already in place (examples of this include the current energy efficiency provisions in the NCC as well as the Commercial Building Disclosure (CBD) Program, and Minimum Energy Performance Standards and energy labelling for equipment).

Estimated impacts

As is standard practice, the impact analysis of the two proposed policy options was undertaken from the perspective of the broader Australian community, with impacts that are transfers between stakeholders (such as between the government and households, and between households that undertook an upgrade and those that did not) netted out. Nevertheless, it is important to consider the implications of some of these transfers on stakeholders, particularly the implications of energy bill reductions on households. As such, an analysis of what the proposed changes mean to an average household was also undertaken.

Table ES 3 identifies the costs and benefits that have been quantified in the RIS and Table ES 4 identifies the impacts that have been assessed qualitatively. The estimated impacts of the proposed policy options are presented in the following sections. Costs and benefits have been expressed in both Net Present Value[15] (NPV) terms in 2021 dollars, and as Benefit Cost Ratios[16] (BCRs).

As noted before, the impacts on Class 4 parts of buildings have not been estimated due to very low construction activity in this segment (the CSIRO Australian Housing Data portal shows that fewer than 400 of these buildings were built between 2016 and 2022).

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[14] Commonwealth of Australia, Department of the Prime Minister and Cabinet 2021, *Regulatory Impact Analysis Guide for Ministers' Meetings and National Standard Setting Bodies*, May.

[15] The NPV is the sum of the discounted stream of costs and benefits of the scenario.

[16] The BCR is calculated by dividing the present value of benefits by the present value of costs and can be interpreted as every one dollar of costs delivers 'X' dollars of benefits.

Table ES 3 Costs and benefits quantified in the RIS

	Economy-wide analysis	Distributional (new household) analysis
Costs		
Capital costs		
Costs of additional energy efficiency measures (including costs of thermal bridging provisions and accounting for learning rates)	✓ (Valued at resource cost, which is assumed to be equal to 90% of the retail costs estimated by Energy Efficiency Strategies (EES) and Tony Isaacs Consulting (TIC))	✓ (Valued at retail cost)
Equipment (plant) savings (offset)	✓	✓
Difficult blocks	✓	✓
Rebates	✗ (Transfer)	✓
Government administration costs	✓	✗
Industry costs (including training costs, redesign costs, transition costs and administrative costs)	✓	✗
Benefits		
Energy benefits		
Direct energy savings (including PV offsets and exports and household offsetting amenity benefit)	✓ (Valued at resource cost using wholesale energy costs as a proxy)	✓ (Valued using retail energy costs)
Change in generation investment	✓	✗
Deferred electricity network investment	✓	✗
Deferred gas pipeline investment	✓	✗
Reduced GHG emissions	✓	✗
Health benefits		
From improved air quality	✓	✗
From reduced gas use	✓	✗
From reduced wood use	✓	✗

Source: ACIL Allen.

Table ES 4 Non-quantified impacts

	Economy	All households
Health benefits		
From improved thermal quality	+ (through reduced health spending)	+ (through reduced mortality & morbidity)
From improved air indoor quality and reduced dampness	+ (through reduced health spending)	+ (through reduced mortality & morbidity)
Reduced financial stress for households experiencing energy bill pressure	+ (through reduced health spending)	+ (through reduced disconnection costs & improved mental health)
Resilience to extreme weather and blackouts	+	+
Impact of changes in wholesale energy prices for households in existing housing	N/A (transfer)	–
Reduced expenditure on energy concessions & hardship programs	+	N/A
Macroeconomic impacts of energy efficiency (investment effects & energy demand reductions)	+/– (Net impacts on economic growth need to be estimated using a suitable general equilibrium model)	+/– (Net impacts on real income need to be estimated using a suitable general equilibrium model)
Additional new business opportunities through demand for additional energy efficiency and renewable energy	+	+
Impacts on building amenity	N/A	– (smaller windows, accessibility, restrictions in decorative lighting)
Increased fire risk	–	–
Increased regulatory complexity for industry	–	–
Decreased consumer choice	N/A	–

Note: A green plus sign indicates a positive impact. A red minus sign indicates a negative impact. Text in blue font refers to impacts raised by stakeholders during consultation.
Source: ACIL Allen

Household (distributional) impacts

Table ES 5 shows the estimated energy bill savings[17] (and other benefits[18]) for an average household in each jurisdiction residing in the dwellings that are modelled to have implemented the proposed NCC changes, compared to the total costs of the upgrades/changes[19] (in present value terms). The effect on these households is measured using retail energy costs (rather than wholesale energy costs and changes in generation and network investment – the approach used in the economy-wide analysis to measure the reduced resource costs). Importantly, the difference between the reduction in retail energy costs, and the reduction in wholesale energy costs and changes in generation and network investment, is, in reality, transferred to others in the community.

The estimated impacts in Table ES 5 show that all Class 1 dwellings under Option A and all Class 2 dwellings under Option B (except dwellings in Queensland) are estimated to experience net benefits from the proposed change (that is, the benefits received by households in these dwellings from the additional energy efficiency measures installed are more than sufficient to cover the additional costs incurred to implement these measures). This table also shows that:

— Under Option A, the proposed changes are estimated to result in net costs for most households in Class 2 dwellings across Australia, except for households in Class 2 dwellings in Tasmania and the ACT who are estimated to experience net benefits from the proposed changes.
— Under Option B, the proposed changes are estimated to result in net costs for households in Class 1 dwellings in Queensland and Tasmania.

This analysis indicates that applying Option A for Class 1 dwellings and Option B for Class 2 dwellings results in net benefits to households in all jurisdictions (except households in apartments in Queensland).

Table ES 5 Estimated lifetime (2022- 2051) distributional impacts for dwellings built in 2022, $ per household, (present value, $2021)

	Capital costs ($)	Energy bill savings ($)	Other benefits ($)	Net impact ($, NPV)	Household BCR
Option A					
Class 1					
NSW	3,319	3,832	347	859	1.26
VIC	3,310	4,263	394	1,347	1.41
QLD	710	790	86	166	1.23
SA	1,808	2,472	253	916	1.51
WA	1,020	1,660	163	803	1.79

[17] Including the value of any exports from solar PV.

[18] Other benefits refer to an amenity benefit that offsets the rebound effect included in the modelling (refer to Section 5.5.1 for more details).

[19] These refer to the full retail costs of the measures and include any rebates/subsidies included in Energy Efficiency Strategies' (EES) modelling.

	Capital costs ($)	Energy bill savings ($)	Other benefits ($)	Net impact ($, NPV)	Household BCR
TAS	3,135	2,984	310	160	1.05
NT	6,762	6,876	599	712	1.11
ACT	1,243	2,262	234	1,253	2.01
Australia	2,199	2,761	261	822	1.37
Class 2					
NSW	4,279	1,904	212	-2,163	0.49
VIC	4,656	1,692	188	-2,776	0.40
QLD [a]	5,004	2,690	299	-2,015	0.60
SA	3,410	2,687	299	-425	0.88
WA	2,869	1,730	192	-947	0.67
TAS	2,106	3,232	359	1,485	1.71
NT	4,828	3,837	426	-565	0.88
ACT	2,889	2,797	311	219	1.08
Australia [a]	4,283	2,062	229	-1,992	0.53
Option B					
Class 1					
NSW	1,119	1,048	100	29	1.03
VIC	1,870	2,386	249	765	1.41
QLD	356	145	15	-196	0.45
SA	846	1,030	112	296	1.35
WA	609	922	98	411	1.68
TAS	1,833	1,319	143	-370	0.80
NT	2,605	2,635	261	291	1.11
ACT	600	1,065	116	580	1.97
Australia	1,059	1,203	124	268	1.25
Class 2					
NSW	534	518	58	41	1.08
VIC	542	587	65	110	1.20
QLD [b]	764	655	73	-36	0.95
SA	585	1,230	137	782	2.34
WA	251	913	101	764	4.04
TAS	1,005	2,060	229	1,284	2.28
NT	1,271	1,936	215	880	1.69

	Capital costs ($)	Energy bill savings ($)	Other benefits ($)	Net impact ($, NPV)	Household BCR
ACT	844	1,307	145	608	1.72
Australia [b]	579	670	74	166	1.29

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[b] Results reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).

Notes: estimates use retail energy prices and refer to dwellings built in 2022. Present values calculated using a 7% discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

As discussed in the following section, there are differences in performance of building classifications under the different policy options. The combined effect of using Option A for Class 1 dwellings and Option B for Class 2 dwellings has therefore also been considered. Table ES 6 provides the annual average energy bill savings over a 30 year period for the combined option. The annual average energy bill savings are higher for Class 2 dwellings than for Class 1 dwellings.

Table ES 6 Estimated average annual energy bill savings over 30 years (over asset lifecycle) of applying Option A for Class 1 dwellings and Option B for Class 2 dwellings, undiscounted ($2021)

	Class 1	Class 2
NSW	255	33
VIC	295	37
QLD	43	34
SA	164	71
WA	105	52
TAS	178	111
NT	449	100
ACT	143	75
Australia	183	40

Notes: Energy bill savings include energy savings from all fuels. Results reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). Totals may not add up due to rounding.

Source: ACIL Allen.

Economy-wide impacts

The costs and benefits that have been quantified at the economy-wide level are briefly outlined below.

- **Benefits** — the analysis uses three main measures of the potential benefits accruing to each policy option:
  - **Energy benefits** – these are benefits from the saved cost of supplying energy. This is the most certain measure of benefits available and includes:
    - the aggregated value of direct energy savings from reduced energy consumption. Notably, in contrast to the household analysis, these benefits are valued using the resource cost (for which wholesale energy prices are used as a proxy) in the economy-wide analysis
    - an amenity benefit that offsets the rebound effect included in the modelling[20]
    - deferred investment in electricity generation, and electricity and gas network capacity as a result of reductions in peak electricity demand and gas usage.
  - **Benefits from reduced carbon emissions** — this is a somewhat more uncertain measure of benefit. It is clear that carbon emissions represent a cost to society, and that reducing these emissions therefore represents a benefit. However, there is no universally agreed transparent price which can be assigned to these emissions.
  - **Health benefits from reduced electricity and gas generation, and wood and gas use** — these are benefits from reduced pollution from electricity and gas generation, and from wood and gas use. While it is clear that air pollution that damages health is produced by generating electricity from fossil fuels, and by burning gas and wood, and that reducing these emissions represents a benefit, these benefits are generally regarded as highly uncertain and speculative and should be interpreted as an indicative potential value of the wellbeing that could be generated through energy efficiency upgrades. The true value in dollar terms of these benefits is unknown, but is expected, based on the information available, to be of the same order of magnitude as our estimates.
- **Costs** — the policy options examined entail costs to households, industry and government. The following costs have been included in the analysis:
  - the aggregate capital costs associated with the proposed policy changes[21]
  - costs incurred by the government to administer the policy and communicate the policy changes
  - costs incurred by industry that cannot be directly passed on to the consumer. These costs include training costs, redesign costs, transition costs and administrative costs.

[20] Refer to Section 5.5.1 for more details.

[21] The capital costs used in the economy-wide modelling refer to the resource costs of the energy efficiency measures. It is assumed that the resource costs of the additional energy efficiency measures installed are equal to 90 per cent of the retail costs of the upgrades.

While the objectives of the NCC include improving occupant health and amenity, and improving the resilience of a building to extreme weather and blackouts, these benefits are less material when moving from the current stringency of provisions in the NCC to those proposed for NCC 2022. Chapter 9 qualitatively discusses how these types of benefits are largely captured, and are more substantial when comparing the proposed energy efficiency provisions in the NCC 2022 with older building stock.

Table ES 7 provides estimates of the economy-wide costs and benefits of the proposed changes for each dwelling class by option. Notably, the present values and BCRs in this table exclude industry and government costs (which are not class-specific). As shown in this table, Class 1 dwellings perform better under Option A and Class 2 dwellings perform better under Option B. This result is mainly driven by the impracticality of using solar PV in Class 2 dwellings, which results in having to use less cost effective solutions to meet the more stringent standards under Option A.

Table ES 7 Estimated lifetime (2022-2060) economy-wide costs and benefits of the proposed policy options by class, present value ($M, 2021), Australia (excluding industry and government costs)

	Unit	Option A	Option B
CLASS 1			
Costs			
Capital (resource) costs	$M	2,140.9	1,016.4
Benefits			
Energy benefits [a, b]	$M	1,112.5	579.2
Greenhouse emissions savings	$M	573.4	228.3
Health benefits [b]	$M	172.7	46.8
Benefits minus cost [c]	$M	-282.4	-162.2
BCR [c]	Ratio	0.87	0.84
CLASS 2[d]			
Costs			
Capital (resource) costs	$M	1,438.7	268.9
Benefits			
Energy benefits [a, b]	$M	274.8	138.8
Greenhouse emissions savings	$M	128.1	50.2
Health benefits [b]	$M	32.4	28.2
Benefits minus cost [c]	$M	-1,003.3	-51.8 [e]
BCR [c]	Ratio	0.30	0.81 [e]

[a] Energy benefits include energy savings from all fuels, household offsetting amenity benefit and changes in generation and network investment for gas and electricity.

[b] Analysis by class assumes that health benefits and the benefits from changes in generation and network investment for gas and electricity are proportional to household energy savings.

[c] NPVs and BCRs by class exclude industry and government costs.

	Unit	Option A	Option B

[d] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1)

[e] Indicatively, resetting the energy performance benchmark in Queensland to be the same as all other states could decrease the net costs for Class 2 dwellings Australia-wide under Option B by around $10 million and decrease the BCR by around 3 per cent (to 0.78).

Notes: Present values calculated using a 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

Given the differences in performance of building classifications under different policy options, Table ES 8 shows the combined effect of using Option A for Class 1 dwellings and Option B for Class 2 dwellings (hereinafter referred to as the Combined Option). Reflecting the level of certainty of different benefits discussed above, the NPV and BCR metrics in Table ES 8 are presented incrementally by adding benefits from the most certain to the least certain.

Table ES 8 Estimated lifetime (2022-2060) economy-wide costs and benefits of applying Option A for Class 1 dwellings and Option B for Class 2 dwellings, present value ($M, 2021), Australia

COSTS	
Households - capital (resource) costs	2,333.0
Industry costs	222.6
Government Costs	0.6
TOTAL COSTS	2,556.2
BENEFITS	
Households	
Energy benefits [a]	1,462.2
Household subtotal	1,462.2
Society	
Change in generation and network investment for gas and electricity	-247.8
Greenhouse emissions savings	604.6
Health benefits from reduced electricity generation and use of wood and gas	190.3
Society subtotal	547.0
TOTAL BENEFITS	2,009.1
NET PRESENT VALUES	
Accounting for energy benefits only	-1,341.9
Accounting for energy benefits + carbon benefits	-737.4
Accounting for energy benefits + carbon benefits + health benefits	-547.1

BCR (RATIO)	
Accounting for energy benefits only	0.5
Accounting for energy benefits + carbon benefits	0.7
Accounting for energy benefits + carbon benefits + health benefits	0.8

[a] Energy benefits include energy savings from all fuels and household offsetting amenity benefit.

Notes: Present values calculated using a 7 per cent discount rate. Results reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). Totals may not add up due to rounding.

Source: ACIL Allen.

Table ES 8 indicates that, at an economy-wide level, this combination of policies results in net costs to the Australian economy of $547 million and a BCR of 0.8, even when including the somewhat more uncertain measures of benefit (the benefits from reduced carbon emissions and health benefits). However, using Option A for Class 1 dwellings and Option B for Class 2 dwellings is the preferred option when compared to the other options analysed (including applying Option A or Option B to both dwelling classifications and the alternative options outlined in Table ES 2) because:

- as shown in Figure ES 1 and Table ES 9, it provides the highest level of greenhouse (GHG) emissions savings at the lowest net cost to the economy. Indeed, while Option B is the option with the lowest net cost to the economy and would result in a reduction of costs of around 20 per cent when compared to the Combined Option, it would deliver less than half the GHG emissions savings
- it results in the highest BCR at the economy-wide level
- at a household level, it would deliver net benefits to households in both Class 1 and Class 2 dwellings in all jurisdictions (except households in apartments in Queensland)
- it helps meet the objectives of the regulation by:
  - reducing energy consumption, reducing GHG emissions through reductions of 4.3Mt CO_2-e to 2030, 13 Mt CO_2-e to 2050 and 14 Mt CO_2-e to 2060 (cumulative, see Figure ES 2)
  - improving occupant health and amenity, and improving the resilience of dwellings to extreme weather and blackouts
- compared to the alternative options outlined in Table ES 2 (e.g. the WoH only option), it results in:
  - built-in efficiency as opposed to efficiency from non-fixed assets, which have shorter lifespans
  - improvements in thermal comfort
  - improved building resilience
  - improved outcomes for the electricity grid.

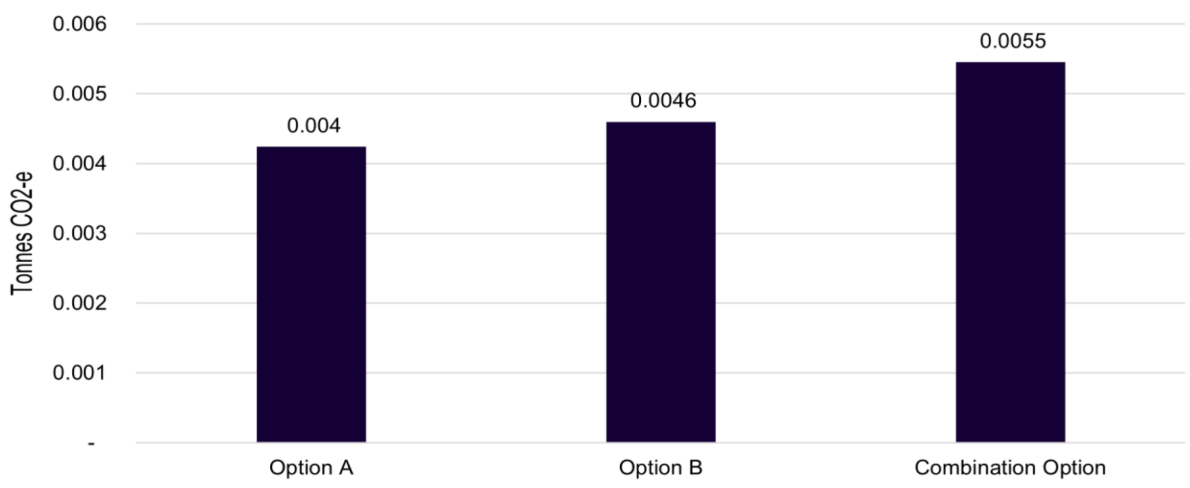
Table ES 9 Comparison of lifetime economy-wide impacts of policy options, Australia

	NPV ($M, 2021)	BCR	Greenhouse emissions savings ($M, 2021)
Option A	-1,508.9	0.6	701.4
Option B	-437.2	0.7	278.5
Option A for Class 1 and Option B for Class 2	-547.1	0.8	604.6

Notes: Present values calculated using a 7 per cent discount rate. Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and the results for the combination option reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). NPVs and BCRs account for energy benefits, carbon benefits and health benefits. Totals may not add up due to rounding.

Source: ACIL Allen.

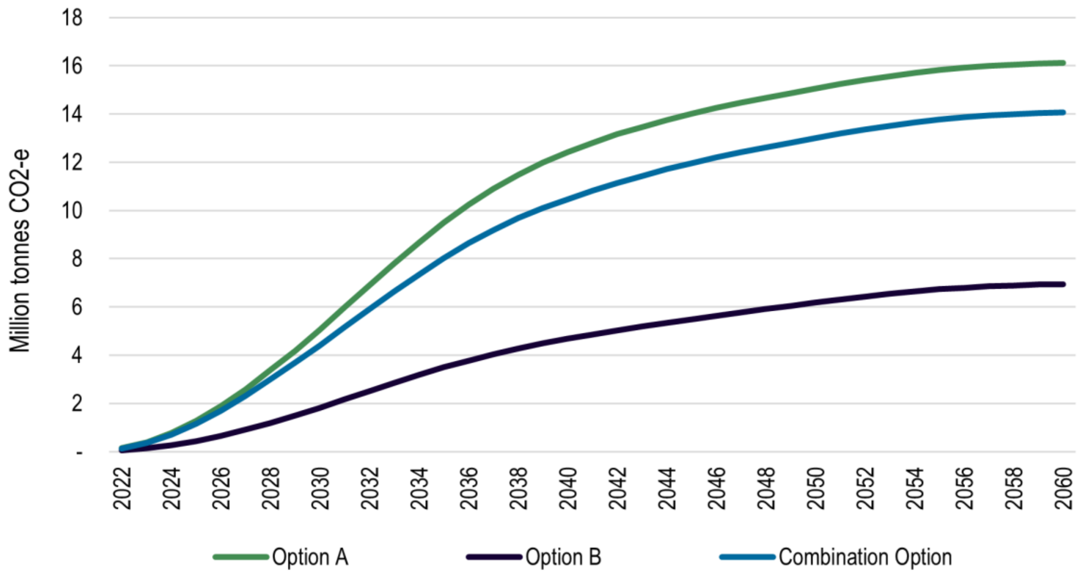
Figure ES 1 GHG abatement per dollar of costs (tonnes CO2-e per $2021)



Notes: Costs are in present values calculated using a 7 per cent discount rate. Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the combination option reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).

Source: ACIL Allen

Figure ES 2 Cumulative GHG abatement by policy option, million tonnes Co2-e



Notes: Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the combination option reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).

Source: ACIL Allen

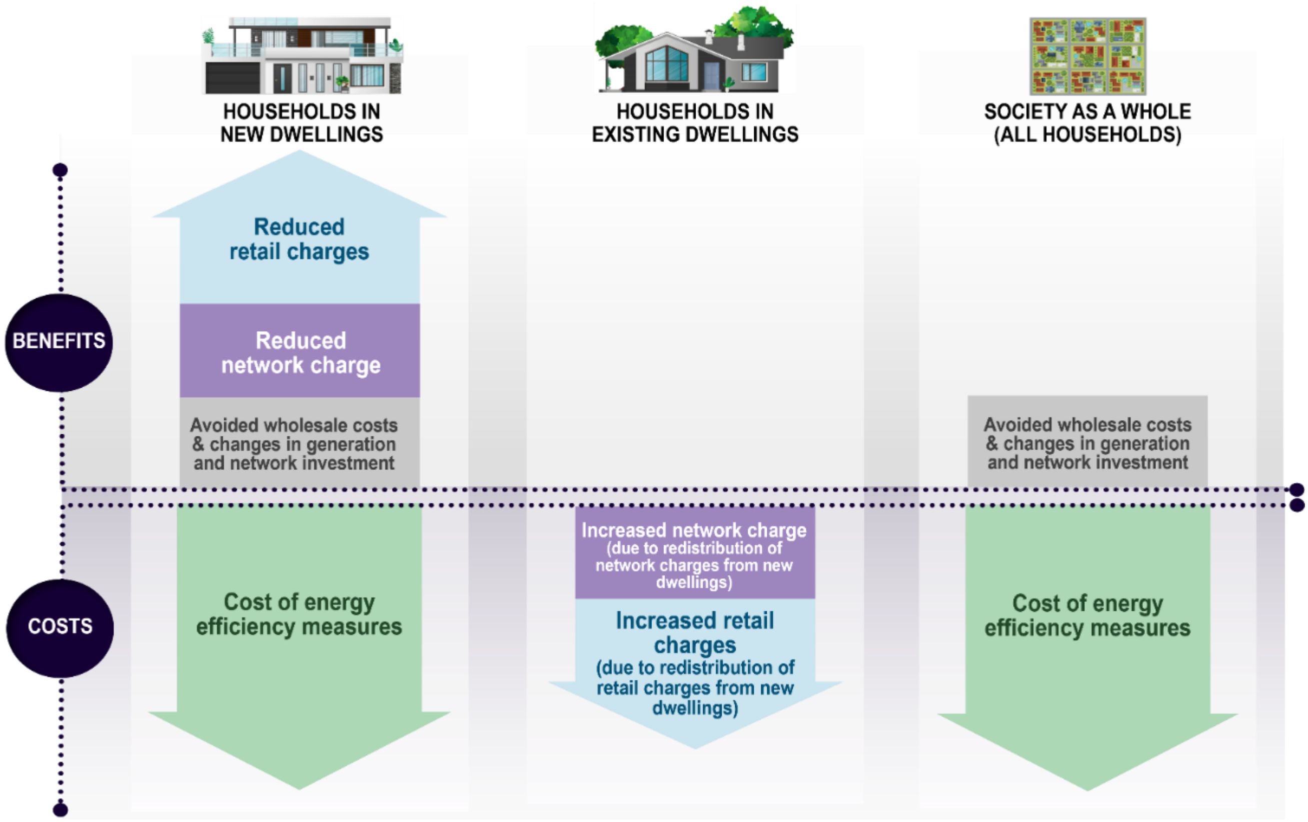
Understanding the difference between economy-wide and distributional impacts

It may appear odd that the impacts of the proposed changes to the NCC are more favourable at a household level than at the societal level. This is because the value of energy savings for households is greater than the resource savings to society overall. Fixed network and retail costs that are saved by households still need to be recovered by energy retailers. Thereby, a large part of the household's benefit is a result of a transfer between individuals — from society as a whole to other energy users. This is illustrated in Figure ES 3.

The energy charges that are reduced for households, but which do not result in costs being avoided, are transferred to other energy users — even those who have nothing to do with the proposed changes to the NCC — through higher energy prices. The benefit to households that are subject to the proposed changes to the NCC is exactly offset by increased costs elsewhere. This type of transfer is called a pecuniary externality. In modelling the net impacts, this transfer at an economy-wide level is accounted for by using wholesale energy prices (as a proxy for avoided resource costs) and changes in generation and network investment, which is why it is used in this cost benefit analysis (CBA).

While it is true that households can be made better off, this is because a large part of this benefit is transferred to the rest of society. The impact analysis has to consider all net impacts, including these transfers, at the society level. As a result, some of the benefit to households must be offset when assessing the policy overall at the society level.

Figure ES 3 Redistribution of costs and benefits



Note: The scale of impacts is illustrative only. The diagram excludes the change in wholesale electricity prices, which is an equal benefit and cost to households in existing dwellings.
Source: ACIL Allen

This approach is consistent with the Australian Government's handbook on cost-benefit analysis, which states:

> One of the first tasks for the analyst is to distinguish the allocative effects of a project, that is, the effects due to changes in the use of resources and in outputs, from the distributional effects. Generally speaking it is only changes in resource use that involve opportunity costs. Distributional effects may be regarded as 'transfers' – that is, some individuals are made better off while others are made worse off. Distributional effects do not add or subtract from estimated net social benefit. However, they may affect social welfare if the judgement is made that one group derives more value from the resources than another group.[22]

The distributional effects referred to in the handbook on cost-benefit analysis would be included in the economy-wide cost benefit analysis if retail electricity prices had been used to value energy savings.

[22] Australian Government, *Handbook of Cost-Benefit Analysis*, January 2006, page 27.

Similarly, the Houston Kemp report for the Australian Government Residential Buildings Regulatory Impact Statement Methodology states that:

> Previous studies have used reduction in the retail bill as the benefit, which represents the financial savings to households based on existing tariffs. However, we believe a more accurate approach is to estimate the resource cost savings from reduced electricity and gas consumption, i.e., reduction in network and wholesale costs.[23]

And that:

> To estimate the benefit from reductions in electricity generation costs, average wholesale market prices can be used as they typically represent suitable estimates for the resource cost savings.[24]

Sensitivity and breakeven analysis

Given the uncertainty associated with many of the assumptions used in the CBA, sensitivity analysis was conducted to assess the sensitivity of the results to substantial changes in the following assumptions (a detailed discussion of the assumptions used in the analysis and their rationale is provided in Chapter 5):

- discount rate
- industry costs
- construction costs
- carbon prices
- energy savings achieved in practice.

The results of the sensitivity analysis are presented in Table ES 10. As shown in this table, the BCR under Option A, Option B and the Combined Option increases with:

- a reduction in the discount rate
- a decrease in industry costs
- an increase in the carbon price
- a reduction in construction costs
- an increase in the energy savings achieved in practice.

However, in most cases, substantial changes to each of the assumptions were not sufficient to result in a BCR of one (or a positive net present value), except for:

- Option B under the case where:
  - a 3 per cent discount rate is used
  - a higher carbon price is assumed (equal to the SCC value for the 95th percentile of the frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate)

[23] Houston Kemp, *Residential Buildings Regulatory Impact Statement Methodology,* 66 April 2017, page 14.

[24] Ibid, page 15.

— the Combined Option under the case where:
  – a 3 per cent discount rate is used
  – a higher carbon price is assumed – either doubled or set equal to the SCC value for the 95th percentile of the frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate.

Table ES 10 Sensitivity analysis — impact of sensitivity tests on the economy-wide NPV under each policy option ($M, 2021)

	Option A	Option B	Option A for Class 1 + Option B for Class 2
NPV under standard assumptions	-$1,509	-$437	-$547
Discount rate			
Decrease from 7% to 3%	-$542	$33	$493
Increase from 7% to 10%	-$1,792	-$585	-$896
7% from year 1 to 30 and 5.4% from year 31 onwards [a]	-$1,487	-$423	-$526
Industry costs [b]			
Decrease costs by 50%	-$1,398	-$326	-$436
Increase costs by 50%	-$1,620	-$548	-$658
Construction costs [b]			
Decrease costs by 15%	-$972	-$244	-$197
Increase costs by 15%	-$2,046	-$630	-$897
Carbon price [b]			
Decrease price by 50%	-$1,860	-$576	-$849
Increase price by 100%	-$808	-$159	$57
SCC at 95% percentile, 3% discount rate	-$83	$130	$682
Performance gap			
Low realisation scenario — 50% of modelled energy savings are achieved in practice	-$2,419	-$888	-$1,315
Medium realisation scenario — 75% of modelled energy savings are achieved in practice	-$1,863	-$612	-$846

[a] The OBPR has recently updated their guidance for incorporating environmental impacts and uncertainty into regulatory impact analysis. In this guidance, the OBPR notes that for analyses involving very long timeframes, uncertainty about the 'true' discount rate means that it is appropriate to use a time declining discount rate. In particular, it recommended that for analyses involving a period of analysis of between 31 and 75 years, the central discount rate declines from 7 per cent to 5.4 per cent after 30 years.

	Option A	Option B	Option A for Class 1 + Option B for Class 2

[b] Changes are modelled as level changes applied evenly for all years, all building classifications, and all jurisdictions and climate zones (i.e. not year on year change).

Note: Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the combination option reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). All changes are modelled as changes from the central case scenario (which includes a rebound effect of 10 per cent). Totals may not add up due to rounding.

Source: ACIL Allen.

Breakeven analysis was also undertaken (see Table ES 11), which indicates that there would need to be a very significant increase in wholesale energy costs and/or a significant reduction in the capital costs for there to be an Australia-wide net societal benefit associated with the proposed policy options.

Table ES 11 Breakeven analysis [a]

	Option A	Option B	Option A for Class 1 + Option B for Class 2
Breakeven in each jurisdiction			
Percentage change in wholesale energy prices to breakeven [b]	151%	183%	108%
Percentage change in capital costs to breakeven	-50%	-62%	-50%
Breakeven economy-wide			
Percentage change in wholesale energy prices to breakeven	92%	65%	37%
Percentage change in capital costs to breakeven	-42%	-34%	-23%

[a] Breakeven point is where the benefits of the policy option minus its costs equal zero (in net present value terms), with a 7 per cent discount rate.

[b] Wholesale electricity prices are around 25-30 per cent of the retail electricity prices.

Note: Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the combination option reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). All changes are modelled as level changes applied evenly for all years, all building classifications, and all jurisdictions and climate zones (i.e. not year on year change). Totals may not add up due to rounding.

Source: ACIL Allen.

Energy market impacts

Concerns have been raised regarding the impact on the wholesale energy market (and the network) of increased uptake of solar PV as a result of the proposed policy changes. Wholesale energy market modelling using our proprietary model, PowerMark, was undertaken to:

— project the change in wholesale electricity prices in the National Electricity Market (NEM) and the Western Australian Electricity Market (WEM)
— any changes in capacity in terms of new investments or retirements of existing generators, and
— any changes on minimum demand levels.

The key findings of this analysis are as follows:

— **Capacity of solar PV systems** installed – the total increase in solar PV capacity estimated to be installed under the proposed NCC 2022 relative to the BAU[25] in 2030-31 is minimal in Queensland, around 2 per cent higher in South Australia and Western Australia, around 5-6 per cent higher in New South Wales and Victoria, and around 17 per cent higher in Tasmania.
— **Impact on wholesale electricity prices** – under the proposed NCC 2022, the time weighted wholesale electricity price is projected to be between 8 per cent lower and 8 per cent higher than the reference case.[26] This compares to changes in wholesale electricity prices of between 35 per cent lower and 185 per cent higher over the period from 2021 to 2050 under the reference case.
— **Impact on wholesale electricity costs** – in aggregate, the changes in wholesale electricity prices are projected to result in an economy-wide increase in electricity costs of $2.2 billion using a 7 per cent discount rate, which represents a 0.6 per cent increase in wholesale electricity costs. This is a cost to electricity customers and a benefit to generators. It is considered a transfer and not included in the analysis, consistent with the *Regulatory Impact Analysis Guide For Ministers' Meetings And National Standard Setting Bodies*.
— **Impact on generator capacity and output** — the proposed NCC 2022 is not projected to bring forward coal-fired power station closures. However, it is projected to bring forward investment in new generation capacity in Victoria.
— **Impact on minimum demand** – the minimum demand is positive under the proposed NCC 2022, except in South Australia, Victoria and Western Australia. The minimum demand level in South Australia is negative with and without the proposed NCC 2022. The proposed NCC 2022 is projected to bring forward negative minimum demand levels in Victoria from 2042 to 2029 (under Option A for Class 1 buildings and Option B for Class 2 buildings) or 2028 (with twice as much solar capacity installed), and in Western Australia from 2034 to 2032 (under Option A for Class 1 buildings and Option B for Class 2 buildings) or 2030 (with twice as much solar capacity installed).

[25] AEMO's steady progress scenario for the NEM and the expected case for Western Australia.

[26] The reference case is with no change to the NCC.

Conclusions

Based on the analysis presented in this RIS, the preferred option to improve the energy efficiency of new residential buildings is applying Option A for Class 1 dwellings and Option B for Class 2 dwellings. While this combination of policies results in net costs to the Australian economy of $547 million and a BCR of 0.8, it is the preferred option when compared to the other options analysed (including applying either Option A or Option B to both dwelling classifications and the alternative options analysed in response to feedback on the CRIS) because:

— it provides the highest level of GHG emissions savings at the lowest net cost to the economy
— it is the regulatory option that results in the highest BCR at the economy-wide level
— at a household level, it would deliver net benefits to households in both Class 1 and Class 2 dwellings in all jurisdictions (except households in apartments in Queensland)
— it helps meet the objectives of the regulation by reducing energy consumption, reducing GHG emissions, improving occupant health and amenity and improving the resilience of dwellings to extreme weather and blackouts
— it meets the criteria for recommending an option other than the one with the highest net benefit (in this case, the base case)[27], as this option:
  – is likely to deliver significant benefits that cannot be monetised
  – would provide higher resilience in the face of uncertainty
  – would provide significant benefits to new households, particularly to vulnerable households, in the form of energy savings
— compared to the alternative regulatory options analysed in response to feedback, it results in:
  – built-in efficiency as opposed to efficiency from non-fixed assets which have shorter lifespans
  – improvements in thermal comfort
  – improved building resilience
  – improved outcomes for the electricity grid.

Notably, beyond the outcomes from the CBA, there are a number of other considerations that are important when making the decision about the stringency of NCC 2022, including:

— the value of unquantified (but well recognised) benefits to households of more energy efficient residential buildings, including improved social equity, amenity, health and wellbeing, and resilience to extreme weather events and in the event of power outages
— Australia's progress towards meeting national and international GHG emissions reduction commitments and the role that the proposed changes would play in achieving these targets
— the value the community places on further energy efficiency improvements in residential buildings
— the significant benefits for new households from energy savings, particularly to vulnerable households
— the historical precedent of approving an increase in energy efficiency from 5 to 6 stars in 2009 despite the final RIS estimating a net loss to the Australian economy from the proposed changes of $259 million (in 2009 dollars) and a BCR of 0.88.

[27] Additional details of the decision rules for RISs are discussed in Box 1.2 in 1.

Decision-makers are best placed to weigh up these factors against the net cost imposed on other members of the community.

1 Introduction

As part of the Paris Agreement[28], Australia has set an economy-wide target to reduce greenhouse gas (GHG) emissions by between 26 and 28 per cent on 2005 levels by 2030 (a target that it is aiming to overachieve), and to achieve net zero emissions as soon as possible, preferably by 2050. An initiative developed to help deliver the committed emissions reductions is the National Energy Productivity Plan (NEPP).

The NEEP was released in 2015 by the former Council of Australian Governments (COAG) Energy Council to ensure Australians are able to effectively manage their energy costs, improve the productivity of their energy use and improve their access to least-cost energy.[29] It outlines a package of measures to improve Australia's energy productivity by 40 per cent by 2030 on 2015 levels, including a number of measures to reduce the energy use of residential buildings. Measures to improve energy efficiency in residential buildings in the NEPP include improving and expanding building ratings and disclosure, and advancing the energy efficiency provisions of the NCC.

In December 2018, the former COAG Energy Council released the Trajectory for Low Energy Buildings (the Trajectory) under the NEPP Measure 31 – Advance the NCC. The Trajectory is a national plan that sets a trajectory towards zero energy (and carbon) ready buildings for Australia and identifies opportunities for the building sector. It proposes:

— setting a trajectory towards zero energy (and carbon) ready buildings
— implementing cost effective increases to the energy efficiency provisions in the NCC for residential and commercial buildings from 2022
— considering options for improving existing buildings.

In response to the Trajectory's recommendations for ongoing improvements to the energy efficiency provisions in the NCC, in early 2019 the former COAG Energy Council requested that the former Building Ministers' Forum (BMF) update the energy efficiency provisions in the NCC. In consideration of the former COAG Energy Council's request, in mid-2019, the BMF agreed to the development of enhanced energy efficiency provisions for new residential buildings, informed by the Trajectory.

In July 2019, the ABCB released a scoping study (Energy efficiency – NCC 2022 and beyond scoping study) to seek public comment on a proposed approach and scope of future changes on the 2022 edition of the NCC. After a period of public consultation, the ABCB released an outcomes report in December 2019 that summarised the information received during the consultation period.

[28] The Paris Agreement is a landmark agreement that came into force in 2016 to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future.

[29] COAG Energy Council 2015, *National Energy Productivity Plan 2015-2030*, P. 6.

The insights gathered through the consultation period on the scoping study were used to inform and refine the scope of proposed changes to the energy efficiency provisions for NCC 2022.

As part of the NCC 2022 development process, the ABCB engaged ACIL Allen to develop a Regulation Impact Statement (RIS) for proposed increases in energy efficiency requirements in the NCC 2022 for new residential buildings.

1.1 Scope of the RIS

The buildings classified as residential in the NCC are outlined in Table 1.1. The analysis of residential buildings in this RIS are based on new Class 1 and Class 2 sole occupancy units (shaded in the table below).

Table 1.1 Classification of residential buildings in the NCC

Class	Description
Class 1a	**A Class 1a building is a single dwelling being a detached house; or one of a group of attached dwellings being a town house, row house or the like.**
Class 1b	A Class 1b building is a boarding house, guest house or hostel that has a floor area less than 300 m2 and ordinarily has less than 12 people living in it. It can also be four or more single dwellings located on one allotment which are used for short-term holiday accommodation.
Class 2	**Class 2 buildings are apartment buildings. They are typically multi-unit residential buildings where people live above and below each other. The NCC describes the space which would be considered the apartment as a sole-occupancy unit (SOU).**
Class 4	A Class 4 part of a building is a sole dwelling or residence within a building of a non-residential nature. An example of a Class 4 part of a building would be a caretaker’s residence in a storage facility. A Class 4 part can only be located in a Class 5 to 9 building.
Class 10a	Class 10a buildings are non-habitable buildings including sheds, carports, and private garages.
Class 10b	Class 10b is a structure being a fence, mast, antenna, retaining wall, swimming pool, or the like.

Source: ABCB 2020, Building Classifications.

1.2 Energy efficiency requirements in the NCC

The NCC provides nationally consistent, minimum technical standards for the design and construction of new buildings (and new building work in existing buildings). In addition to structural, fire protection, and health, amenity and accessibility provisions, Section J of Volume One and Parts 2.6 and 3.12 of Volume Two of the NCC address minimum mandatory provisions for energy efficiency. The NCC achieves these nationally consistent minimum standards by specifying Performance Requirements for various types of building work which can be satisfied using a Performance Solution, a Deemed-to-Satisfy (DTS) Solution or a combination of both (more details on these compliance methods is provided in Box 1.1).

Box 1.1 Methods of compliance with the NCC performance requirements

DTS Solutions

DTS Solutions follow a set of provisions that identify construction practices, materials, components, design factors and construction methods that, when followed and adhered to, are considered sufficient to achieve the required Performance Requirements. There are two options to meet the NCC requirements via DTS solutions:

— DTS energy rating — this option entails obtaining an energy rating of at least 6 stars using a software tool accredited under Nationwide House Energy Rating Scheme (NatHERS), coupled with complying with certain provisions for energy-saving features, and provisions for building sealing.

— DTS elemental provisions — this option entails complying with the relevant DTS elemental provisions detailed in the NCC (which prescribe specific energy efficiency performance levels of materials to be included in the home, such as insulation and glazing).

Performance Solutions

This method provides the ability to propose Performance Solutions to meet the Performance Requirements. The key to the Performance Solutions is that there is no obligation to adopt any particular material, component, design factor or construction method. A building can be approved if it differs in whole or in part from the DTS provisions described in the NCC if it can be demonstrated that the design complies with the relevant Performance Requirement. This means that Performance Solutions can be flexible in achieving the outcomes and encouraging innovative design and technology use.

A Performance Solution must comply with all relevant Performance Requirements and must be verified using one or a combination of the following Assessment Methods:

— evidence of suitability

— a verification method

— expert judgement

— comparison with the DTS provisions.

Source: ACIL Allen based on NatHERS (National Construction Code page, https://www.nathers.gov.au/governance/national-construction-code-and-state-and-territory-regulations) and ABCB
(Home page, http://www.abcb.gov.au/).

Minimum energy efficiency requirements for residential buildings were introduced in 2003 for houses and 2005 for multi-residential buildings. Requirements for non-residential buildings were introduced in 2006 and the requirements were increased to a 5 star standard for both Class 1 and 10. In 2010, the energy efficiency requirements for residential buildings were increased to 6 stars and provisions for commercial building provisions were lifted to a higher level of stringency. The current minimum energy efficiency requirements for residential buildings in the NCC are:

— for Class 1 buildings, generally equivalent to a 6 star rating with some DTS elemental provisions in addition to NatHERS assessments, or compliance with the DTS elemental provisions
— for Class 2 buildings, an average rating of all units in the block of at least 6 stars, and a minimum for each unit of 5 stars. In addition to the assessment of building fabric, multi-residential buildings are also required to meet a series of DTS requirements.

While the NCC is a national code, states and territories can choose to apply its provisions, with or without amendments, for policy or technical differences. As a result of this, the NCC provisions are applied with variations in some jurisdictions:

— the minimum requirements in the Northern Territory (NT) are 5 stars for Class 1 and for Class 2, 3 stars for sole occupancy units and an average of 3.5 stars across all units
— Queensland allows a Class 1 building to get 1 star credits for installing solar photovoltaics (PV); or in a Class 2 building an average of 1 star less than the minimum national requirement
— New South Wales (NSW) has separate Performance Requirements and compliance options based on its Building Sustainability Index (BASIX).

1.3 RIS requirements

The Inter-Governmental Agreement (IGA) that supports the continuing operation of the ABCB require the preparation of a RIS on proposals to alter the NCC.

This RIS has been developed in accordance with the best practice regulatory principles administered by the Office of Best Practice Regulation (OBPR) and set out in the *Regulatory Impact Analysis Guide For Ministers' Meetings And National Standard Setting Bodies* (referred to as the RIA Guidelines or OBPR Guidelines).[30]

The RIA Guidelines require that the RIS answers seven key questions:

1. What is the problem? (addressed in Chapter 3)
2. Why is government action needed? (addressed in Chapter 3)
3. What policy options are to be considered? (addressed in Chapter 4)
4. What is the likely net benefit of each option? (addressed in Chapters 6 and 8)
5. Who was consulted and how was their feedback incorporated? (addressed in Chapters 2 and 6)
6. What is the best option from those considered? (addressed in Chapter 11)

[30] Commonwealth of Australia, Department of the Prime Minister and Cabinet 2021, *Regulatory Impact Analysis Guide for Ministers' Meetings and National Standard Setting Bodies*, May.

7. How will the chosen option be implemented and evaluated? (addressed in Chapter 10)

Additional details about the decision rule to identify the best policy option are provided in Box 1.2

Box 1.2 What is the best option from those considered?

A RIS must recommend a preferred option from among those presented and analysed. Typically, the decision rule to identify the preferred policy option is to select the option with the highest net benefit to society as a whole. However, there are some circumstances where an option, other than the one with the highest net benefit, could be recommended. The circumstances where a 'second best' option could be recommended include:

— When the option would deliver significant benefits that cannot be monetised. The OBPR's CBA guidance notes that 'if a proposal is advocated despite monetised benefits falling significantly short of monetised costs, the RIS should explain clearly why non-monetised benefits would tip the balance and the nature of the inherent uncertainties in the size of the benefits'[31].

— When the option would provide higher resilience in the face of uncertainty. As noted by the OBPR, an option can be recommended that has a lower expected value of net benefits, but with a smaller chance of imposing a significant net cost on the community (lower 'downside risks').[32]

— Where the option with the highest net benefit disproportionately impacts a (vulnerable) sector of the community. Indeed, the OBPR's CBA guidance indicates that decision makers 'may decide to reject an option with the largest NPV if it has significant adverse equity impacts.'[33]

Source: ACIL Allen based on Commonwealth of Australia, Department of the Prime Minister and Cabinet 2020, Cost-benefit analysis guidance note, March.

In accordance with the RIA Guidelines, the RIS has been developed in two stages:

— a Consultation RIS (CRIS) for the purpose of consulting with interested stakeholders (published in September 2021)

— a Decision RIS incorporating relevant information and data gathered through the consultation process with interested stakeholders (this report). This Decision RIS will be used by the ABCB as an input into its decision on the matter that is the subject of the RIS.

Both RISs have been assessed by the OBPR for compliance with the Regulatory Impact Analysis (RIA) requirements for best practice regulation.

[31] Commonwealth of Australia, Department of the Prime Minister and Cabinet 2020, Cost-benefit analysis guidance note, March, p. 12.

[32] Ibid., p. 9.

[33] Ibid., p. 13.

1.4 Structure of this report

The remainder of this report is structured as follows:

— Chapter 2 discusses the key issues raised in the stakeholder responses that were received through the consultation period for the CRIS
— Chapter 3 outlines the nature and extent of the problem that the proposed changes are seeking to address
— Chapter 4 specifies the objectives of government action and the options to address the identified problem
— Chapter 5 outlines the framework used to analyse the impacts of the proposed changes
— Chapter 6 assesses the impacts of the proposed changes to the NCC on individual dwellings.
— Chapter 7 considers the economy-wide impacts of the proposed NCC changes.
— Chapter 8 assesses the distributional and housing affordability impacts associated with the proposed policy changes.
— Chapter 9 provides some discussion of other impacts and policy considerations.
— Chapter 10 discusses the implementation and review of the proposed regulation.
— Chapter 11 sets out the conclusions of the analysis.

2 Feedback on the Consultation RIS

This chapter discusses the key issues raised in the stakeholder responses that were received through the consultation period for the CRIS. The objective of the consultation process in developing the RIS is to ensure that the data, assumptions, methodology and results are as accurate as possible in measuring the impacts of the regulation.

The CRIS was open for public comment from 20 September 2021 until 7 November 2021 and conducted through the ABCB's Consultation Hub platform.[34] Consultation focused around 38 structured questions to assist the public to provide feedback on the CRIS. There were a total of 110 responses from stakeholders on the CRIS. These responses were received from a wide range of stakeholders, including industry associations, not-for-profit organisations, state government departments, local councils, political parties, and product manufacturers and professionals associated with the building industry.

Among the 110 submissions, there were 62 public submissions, 30 anonymous submissions, and 18 confidential submissions. Submissions are identified in this report as follows:

- public submissions are identified by the respondent's name
- anonymous submissions by their unique ID number on the ABCB consultation website
- confidential submissions are not published and are not identified explicitly in this report. The phrase 'a/one/another submission' is used when referencing feedback from a confidential submission.

The feedback provided by stakeholders was diverse and on a number of issues opinion was polarised.

All feedback was taken into consideration in preparing this Decision RIS. After reviewing the submissions, we identified key issues for the analysis, considered any additional evidence provided and determined an approach to address these issues. The sections below discuss the key issues raised by stakeholders during consultation. A summary of the key areas of feedback on the CRIS in table form is provided in Appendix B.

[34] All the answers to the questions asked during consultation can be viewed at https://consultation.abcb.gov.au/engagement/consultation-ris-proposed-ncc-2022-residential/.

2.1 Key issues raised by stakeholders

In considering feedback received during consultation, we identified the following key issues raised by stakeholders:

— questions surrounding the identification of the problem, the scope of market failure and the case for government action
— changes in the design of policy options included in the CRIS
— analysis of alternative policy options
— presentation of disaggregated impacts
— the accuracy of technical inputs
— the reasonableness of the assumed policy response
— climate change impacts
— the need to account for a range of non-market impacts
— consideration of unintended consequences.

These issues are discussed in more detail in the sections below.

2.1.1 Problem identification and scope of market failure in new residential buildings

The majority of stakeholders (see Figure 2.1) are of the view that the CRIS did not adequately identify and define the problem that the proposed regulations are seeking to address and that there are other problems that the CRIS has not considered. A number of stakeholders[35] are of the view that the CRIS:

— did not adequately communicate the need to decarbonise the built environment to address climate change and to achieve the net zero emission commitments by 2050 that all states, territories and the federal government have now made
— understated the range and scale of problems that need to be addressed, particularly with respect to social equity, health and wellbeing of households, and resilience to extreme weather.

One submission suggests that the CRIS understates the problem and notes that Australia is well behind comparable countries, with estimates showing that Australian housing is around 40 per cent less efficient than equivalent standards in comparable countries.

[35] For instance, Renew, New England Greens, the National Association of Steelframed Housing (NASH), submission ANON-7GZH-JXVR-A and another submission.

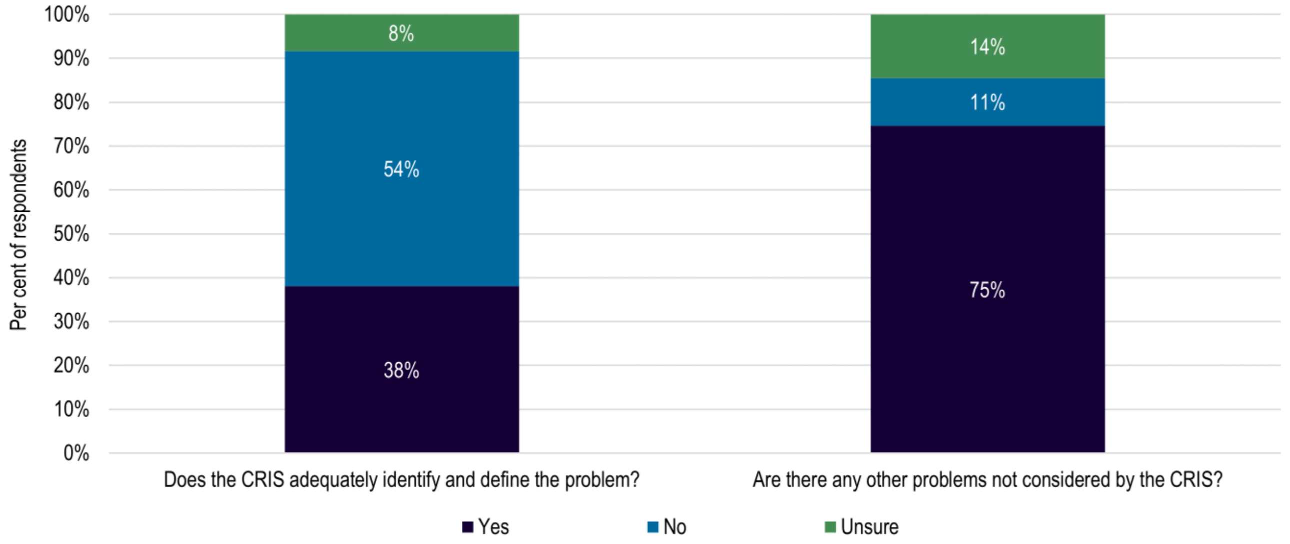
The Earth Building Association of Australia (EBAA) also argues that a number of issues were not addressed in the identification of the problem in the CRIS, including the following:

— Unpriced negative effects — heat island effects from heat dumped by air conditioners, peak load demand of air conditioners[36], the global warming impact of refrigerants, and problems related to airtight buildings (condensation, poor air quality, safety in heatwaves and airborne diseases).
— Information problems — it is argued that:
  – the CRIS modelling is based on NatHERS Regulation Mode modelling which cannot assess passive low energy buildings and which has been shown by CSIRO as unreliable in predicting cooling loads. In this respect we note that, while the Chenath engine (the calculation module of NatHERS tools) is used for the technical modelling underpinning the CRIS, the occupancy patterns were modified to use more realistic hours of use and cooling thermostats. CSIRO found that NatHERS in regulatory mode underpredicts cooling because the NatHERS cooling thermostats are too high. Thermostats were lowered in the evaluation of energy savings for the CRIS, therefore addressing this concern.
  – there is a lack of understanding of the principles of passive solar design and that the assumption that meeting minimum envelope thermal performance is the only or best way to deliver low energy buildings is false. In this respect it is noted that Tony Isaacs Consulting's (TIC) report of the impacts of building fabric upgrades (which was released with the CRIS) included analysis of a sample of specialist passive solar and well-ventilated designs with ideal window orientation. These specialist designs showed cost savings of between 25 per cent and 50 per cent compared to the typical houses. While these passive designs were not included in the dwelling sample underpinning the impact analysis in the CRIS, they were included in the technical modelling to help address this information problem.
— Split incentives — EBAA argues that the regulation is forcing high energy buildings onto consumers who may not be able to afford the cost of maintaining and operating mechanical ventilation or/and air conditioning and that modern buildings are driven by investors, developers and builders and not really designed for people.
— Embodied energy — EBAA argues that embodied energy in high energy materials (e.g. concrete) and hungry energy processes (e.g. air conditioning) must be considered as part of the problem.

In response to this feedback, the problem statement chapter was reviewed and amended as required to refer to the issues raised above, particularly with respect to social equity, health and wellbeing, climate change and resilience of homes and the grid to weather extremes. In addition, the discussion of the policy response in the DRIS has been updated to reflect the changes in governments' policies, including noting that all Australian state and territory governments are now committed to net zero emissions by 2050 or earlier.

[36] Notably, the impact of the proposed increased energy efficiency requirements on peak load was considered as part of the energy modelling undertaken for this DRIS.

Figure 2.1 Submissions views on the problem statement in the CRIS



Note: Responses refer to question 1, does the CRIS adequately identify and define the problem? And question 2, are there any other problems not considered by the CRIS? Chart excludes submissions that did not answer this question. Between 83 and 84 submissions answered these questions.
Source: Citizen Space submission data.

In contrast with the views above, the Housing Industry Association (HIA) argues that the CRIS did not properly establish the existence of a problem justifying further government intervention. They argue that the problems noted in the CRIS have already been addressed in large part by the existing energy efficiency provisions, that the high level of industry over compliance suggests that there is no justification for new regulation to address informational problems and that if previous upgrades/energy efficiency provisions have not addressed split incentives, a different approach should be adopted rather than increasing the standard again. The HIA argue that, if it cannot be demonstrated that problems do exist, rather than may exist, then no further regulation should be implemented.

In response to the HIA’s feedback we note that:

— While it could be argued that the current levels of industry over compliance (which was acknowledged and accounted for in the impact analysis in the CRIS) are a sign that the existing energy efficiency provisions have somewhat addressed informational problems, the fact that overcompliance is not very significant in the highest volume construction areas of Victoria and NSW (or South Australia) for Class 1 dwellings shows that this problem has not been fully addressed by the current regulations. Furthermore, while the market may deliver further improvements, it is not clear that without regulatory intervention these improvements will occur at a pace needed to achieve internationally agreed GHG emissions reduction targets.

— In its Inquiry into the Private Cost Effectiveness of Improving Energy Efficiency, the Productivity Commission (PC) noted that split incentives can occur where there is an information asymmetry, but this is not essential, and that even where the buyer and seller have the same access to information, the transaction costs of overcoming their different incentives may result in the non-adoption of what would otherwise have been a worthwhile investment. Furthermore, the PC suggest that this is where the case for government intervention is the strongest (i.e. where it lessens these transaction costs).[37]

- It is difficult to find *direct* evidence about the extent to which market failures contribute to the energy efficiency gap (the difference between potential and actual energy efficiency in buildings[38]) as decision-making processes cannot be directly observed. However:
  - We consider that market failures are plausible explanations for sub-optimal adoption of cost effective energy efficiency measures in residential buildings, particularly given the complexity of weighing up the costs and benefits of energy efficiency choices and competing priorities of design.
  - The presence of market failures is well-accepted both in Australia and internationally. In fact, in its Inquiry into the Private Cost Effectiveness of Improving Energy Efficiency, the Productivity Commission noted that[39]:

    > Rather than debate the size of these [energy efficiency] gaps, the Commission considers it more productive to accept that they exist, and then ask why they exist, and how government intervention could help increase uptake of energy efficiency improvements in a way that is best for the Australian community.

Consistent with the Productivity Commission's observation, rather than focusing on attempting to quantify the size of the energy efficiency gap, the key focus of the DRIS is to assess whether the proposed changes to the NCC 2022 are likely to deliver a net benefit to the community.

The Lighting Council Australia (LCA) also argues that the CRIS does not properly establish the existence of a problem, but this submission argues that this is the case because the CRIS:

- does not consider the redundancy of the current lighting energy efficiency provisions and its negative impacts
- does not consider that there is no lighting market failure in the new build and renovation markets
- and does not consider the relevant counterfactual (i.e. no lighting energy efficiency provisions).

While the concern of the LCA is acknowledged, the proposed requirements do not include the exclusion of the lighting from the energy efficiency provisions as a policy direction. The ABCB reviewed its policy position in recognition of the LCA's feedback and considered that the arguments and evidence provided were not sufficient to diverge from the policy direction set by the Trajectory. Additional commentary in respect to the LCA proposal is provided in Section 4.2.3.

[37] Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Inquiry No. 36, 31 August 2005, p. 52.

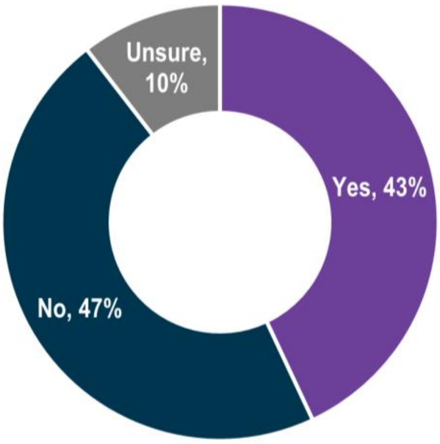
[38] In its Inquiry into the Private Cost Effectiveness of Improving Energy Efficiency (2005), the Productivity Commission defined the energy efficiency gap as 'the gap between actual energy efficiency and the level of energy efficiency believed to be achievable and affordable' (p. XXIV) and further described as 'the difference between actual energy efficiency and what is considered to be the most energy-efficient processes and technologies that are achievable' (p. 68).

[39] Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Inquiry No. 36, 31 August 2005, p. XXV.

2.1.2 Case for government intervention

Figure 2.2 shows that the majority of submissions indicated that the CRIS did not establish a case for amending the energy efficiency provisions of the NCC. However, it is important to note that stakeholder comments on this question seem to refer to the results of the impact analysis, rather than to the establishment of a case for further intervention – that is, feedback relates to the fact that the CRIS found that the proposed regulations would result in net costs and this was interpreted as not establishing a case for amending the energy efficiency provisions in the NCC[40].

Figure 2.2 Does the CRIS establish a case for amending the energy efficiency provisions of the NCC?



Note: Responses refer to question 3, does the CRIS establish a case for amending the energy efficiency provisions of the NCC? Chart excludes submissions that did not answer this question. 86 submissions answered this question.

Source: Citizen Space submission data.

A joint submission by the Property Council of Australia (PCA), the Australian Sustainable Built Environment Council (ASBEC), the Green Building Council of Australia (GBCA) and the Energy Efficiency Council (EEC) argued that the CRIS does not sufficiently establish a case for amending the energy efficiency provisions of the NCC as 'the use of questionable assumptions and underestimating benefits and overestimating costs means it is not as powerful as it could be for supporting change'[41]. It is suggested that aspects that need to be revisited and quantified in the RIS are the benefits of liveability, household energy affordability and energy system (grid) stability, reduced public spending on energy efficiency programs, innovations and technology, and job creation.

[40] Notably, in response to feedback from consultation, a range of changes have been made to the modelling of the regulations, which have resulted in significantly different results to those in the CRIS. Additional commentary about what these changes are is provided in Chapter 5.

[41] Joint submission by PCA, ASBEC, GBCA and EEC, response to question 3.

Renew argue that, as demonstrated by the Trajectory[42] and the NEPP, energy standards must be raised in the NCC to support decarbonisation and better outcomes for households, and that the CRIS should address the question of how energy standards in the NCC could be raised most cost effectively.

Submission ANON-7GZH-JXVR-A argues that the CRIS should have focused primarily on emissions reductions and not on energy efficiency improvements and disagrees with the broadening of the objectives of the NCC — it was argued that the primary objective of the NCC is to reduce GHG emissions not energy efficiency.

As noted in the previous section, HIA argues that the CRIS does not properly justify the case for further government intervention.

BlueScope Steel argues that the CRIS does not establish a case for amending the energy efficiency provisions in the NCC as it lacks consideration of carbon emissions associated with extra building fabric materials required to meet 7 stars and the outdated data of grid decarbonisation significantly overstates carbon reductions. In benign climates (like climate zone 2) or locations that already have a decarbonised grid (Tasmania and South Australia) increased building fabric energy efficiency may lead to increased carbon emissions.

In response to this feedback, the problem statement chapter in this DRIS has been reviewed to include a discussion of these issues (where relevant).

2.1.3 Policy options design

Several submissions commented on the design of the policy options analysed in the CRIS.

In relation to the treatment of different energy sources:

— the joint submission by PCA, ASBEC, GBCA and EEC seems to suggest the use of an all-electric benchmark for Option A
— Renew and the New England Greens argue that the fuel neutral approach of the proposed NCC fails to address the problem of residential gas use and the need to rapidly electrify Australia's housing stock to decarbonise the sector. They also note that the CRIS does not consider the future costs of removing gas connections, which will be required to achieve a net zero emissions commitment
— Energy Networks Australia (ENA) argues that the proposed NCC 2022 is not technology neutral because the energy budget creates a bias against gas and does not include metrics to account for the performance of the building shell.

In respect to these comments, the ABCB notes that the differential treatment of different energy sources is driven by use of the societal cost metric. The societal costs of operating a building are the combined cost of the fuels used and the costs associated with the greenhouse gas emissions of each

[42] COAG Energy Council 2019, Report for Achieving Low Energy Existing Homes, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20Report%20for%20Achieving%20Low%20Energy%20Existing%20Homes_1.pdf.

fuel type. Greenhouse gas emission costs are calculated by multiplying the energy use by the GHG intensity of each fuel type by a dollar value per tonne of GHG emissions (CO2-e).[43]

The societal cost is considered the best metric to evaluate equipment efficiency considering the four policy objectives the NCC is being asked to help meet (lower energy use/cost, lower peak demand, more resilient buildings and lower GHG emissions).

Submission ANON-7GZH-JXVR-A argues that the NCC should be mandating bi-directional charging points in every home and apartment garage space to accelerate the transition to electric vehicles. In this respect we note that new provisions are being proposed in the NCC 2022 to enable Class 2 and 5 to 9 buildings to be easily retrofitted with electric vehicles (EV) charging equipment. The changes are intended to ensure buildings can be easily retrofitted with EV charging and charge control equipment, as EV are likely to become common as transport in the next two decades. The provisions do not require EV charging equipment, but are designed to facilitate easier installation of such equipment in future through additional switchboard capacity and space.

The National Association of Steel Framed Housing (NASH) argues that the CRIS has looked at only one approach to managing energy consumption in dwellings – the incremental insulation and re-glazing of the building shell, viewed through 'the narrow prism of the NatHERS energy modelling system, plus the accounting for a select number of appliances'[44]. NASH argues that NatHERS is a flawed energy modelling system that steers building design in fundamentally wrong directions and does not address health, amenity and resilience impacts. In this respect it is noted that the use of NatHERS is not required to comply with the NCC requirements. Indeed, compliance with the NCC can be demonstrated through the DTS provisions, verification using a reference building (VURB) and Performance Solutions.

Feedback associated with policy design was referred to the ABCB for consideration. Section 4.2 reflects the decisions made by the ABCB in respect to the design of the policy options analysed.

2.1.4 Analysis of alternative policy options

As shown in the top panel of Figure 2.3, the majority of submissions (65 per cent) indicated that there are other feasible options to address the problems identified in the CRIS. Of those submissions that provided additional commentary about what these options are:

— a net zero option was the most frequently suggested alternative to be analysed in the RIS (it was suggested by 23 per cent of the submissions)
— 13 per cent of the submissions suggesting alternatives mentioned that electrification should be considered in the analysis
— around 12 per cent suggested the inclusion of an option that incentivises passive construction principles and the use of natural materials

[43] For further details about how the societal cost of energy is defined, please refer to the ABCB Scoping Study (https://consultation.abcb.gov.au/engagement/energy-efficiency-scoping-study-2019/).

[44] NASH submission, answer to question 2.

- 12 per cent suggested an option that only includes the WoH requirements (with the thermal envelope requirements remaining at 6 stars)
- 10 per cent of submissions suggested taking into consideration embodied carbon, with some stakeholders suggesting that increasing the materials used in construction (e.g. more insulation, higher quality glazing) would increase emissions overall once embodied carbon is taken into consideration
- 8 per cent of the submissions suggested a reduction in star rating
- around 5 per cent noted that addressing the poor energy efficiency of older existing homes should be part of the solution, or should be pursued instead of a change to the NCC
- 4 per cent suggested to follow the policy options in the Trajectory and another 4 per cent argued that the stringency of the WoH requirements should be lowered
- around 3 per cent of submissions suggested the use of an all-electric benchmark to set up the required energy budget
- 2 per cent of submissions suggested that gas should be treated equally to electricity and another 2 per cent suggested the removal of lighting from the energy efficiency provisions
- one per cent of the submissions suggested that energy savings can be made through improving airtightness of dwellings, which would ensure that the energy efficiency of built dwellings is the same as modelled dwellings. A proportion of these submissions suggested airtightness improvements instead of increasing the star rating, while others suggested improvements in addition to increasing the star rating
- one per cent suggested advertising energy consumption for all homes as part of the solution.

PCA, ASBEC, GBCA and EEC support Option A, note that the status quo should not be considered an option as it would lock households into higher costs and lock in GHG emissions and asked that the following additional options be explored:

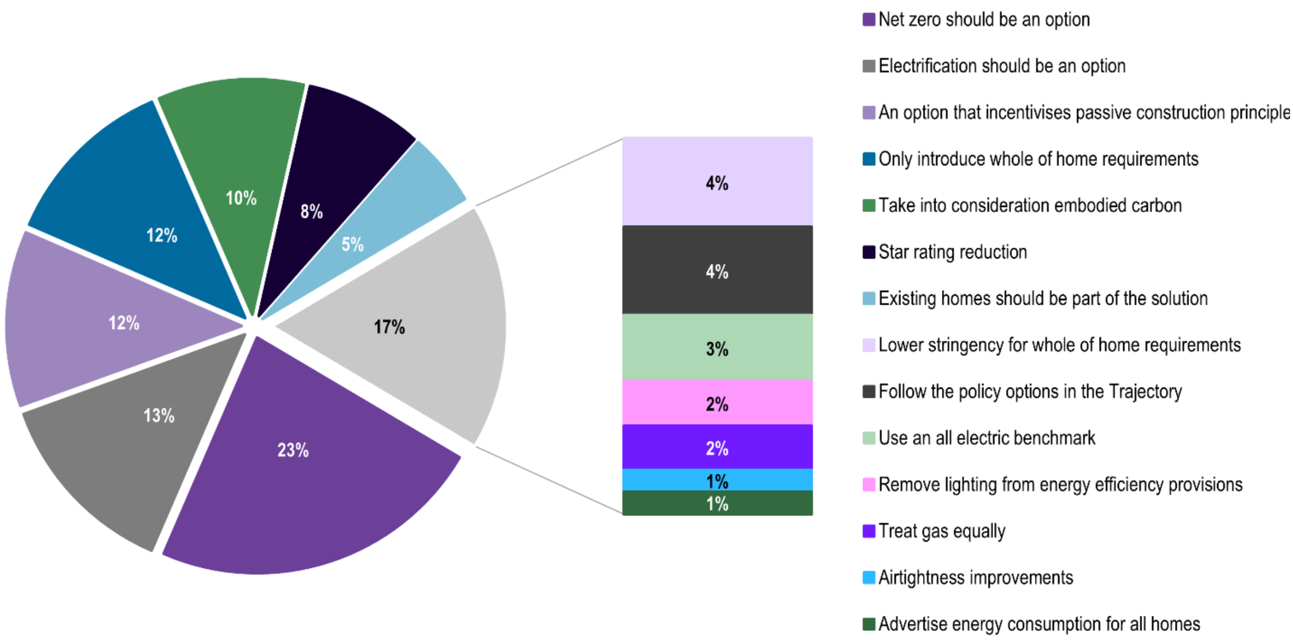
- climate-zone-specific standards (similar to the tailored approach explored in the Trajectory)
- a more ambitious reform option with an annual budget below 70 per cent of the Option B benchmark. They also note that 'The options can be enhanced by further strengthening thermal efficiency requirements; further strengthening whole-of-home requirements to achieve net zero regulated energy; and require renewables-powered all-electric homes.'[45]

HIA does not support the minimum 7 star requirement for the building fabric and argue that a better approach is to move to a more WoH approach similar to BASIX in NSW. They argue that the proposed WoH approach fails on two accounts:

- The NCC 2022 proposals are not significantly different from the NCC 2019 provisions apart from applying a higher stringency for both the fabric and equipment, and the only available offset is for the installation of solar panels for regulated building services.
- The assessment metrics remain solely focused on energy usage as a proxy for emissions reduction, with no direct reference to emissions in the calculation methods.

[45] PCA, ASBEC, GBCA and EEC submission, answer to question 5.

Figure 2.3 Views on alternative policy options



[a] Data refers to responses to question 6, Are there any other feasible options to address the problems identified in the previous chapter that have not been assessed in the CRIS and should be considered? Chart excludes submissions that did not answer this question. Between 44 and 50 submissions answered this question.
[b] Percentages refer to the number of times certain alternative policy options were suggested in submissions. Some submissions suggested more than one alternative option.
Source: Citizen Space submission data.

HIA argues that, to move towards zero energy (and carbon) ready buildings, the approach to energy efficiency in the NCC needs to fundamentally change – simply moving the dial up one star is not the right solution. They also note that a more pragmatic approach would be to align the NCC provisions with the agreed recommendations for the thermal fabric settings being tailored for each climate zone as set out and agreed to in the Trajectory.

In its submission, HIA identifies a range of reforms to achieve zero energy (and carbon) ready buildings at a 'much lower cost'. These include:

1. Introduce the new whole-of-home/energy usage provisions with the building fabric set at 6 stars.
2. Introduce the thermal bridging mitigation measures for both steel and timber framing to provide a true 6 star performance.
3. Combine the NatHERS house rating tools and whole-of-home assessment tools incorporating energy usage/building services provisions, building fabric assessment, heating and cooling loads, thermal bridging and building sealing.[46]

[46] In this respect, it is important to note that NatHERS is already working on including whole of home and thermal bridging into their tool in addition to thermal performance and they have also included heating and cooling load limits. However, not all energy efficiency requirements can be captured by NatHERS software and building sealing is one area that still needs to be done in addition to NatHERS ratings.

4. Incorporate the new NatHERS climate files into the energy rating tools.[47]
5. Complete the re-write of the Deemed-to-Satisfy (DTS) elemental provisions, having these set at 6 star taking account of new knowledge on the current DTS design level.
6. Introduce new enhanced detailed installation of insulation provisions.
7. Introduce the new condensation provisions, air spaces and building wall wrap permeability requirements and undertake a broader analysis of condensation risks of higher energy efficiency standards and a full cost benefit assessment of all future changes.
8. Introduce the new Universal Certificate template and associated checklists.
9. Introduce the new energy assessor whole-of-home Certificate IV training units and undertake a national training program for assessors on the new NCC energy efficiency provisions.
10. Commence a review of the Australian Standards for solar panel installation and battery storage and commence the development of the associated NCC DTS Provisions, where PVs and battery storage systems are installed in houses for future incorporation in the NCC to provide a single source of truth and location for onsite installation provisions.

Renew, the New England Greens and submission ANON-7GZH-JXVR-A argue that stronger options should be considered and presented for public feedback, including the net zero regulated energy option put forward in the Trajectory and the ABCB Scoping Study. Renew and the New England Greens also argue that business as usual should not be considered as an option in the analysis as it locks in poor performance, high energy costs, and GHG emissions that must be urgently reduced. Both stakeholders suggest that, at a minimum, the NCC 2022 should implement Option A for Class 1 buildings and Option B for Class 2 buildings.

The Strata Community Association argue that, given the substantial differences between Class 1 and Class 2 buildings and the complexity of electrical and energy systems in Class 2 buildings, the policy options should be differentiated between these classifications. They support Option A for Class 1 buildings and Option B for Class 2 buildings.

BlueScope Steel argues that an option of 6 stars plus WoH should be analysed as increasing to 7 stars would create significant change in construction practice with limited energy savings. It is also argued that the benefits of 7 stars are unclear and that this increase can lead to undesirable outcomes (e.g. no-eaves and dark colours reducing heatwave performance and smaller windows limiting natural light and ventilation). BlueScope Steel also argues that none of the options analysed directly address improving occupant health and amenity and improving the resilience of a building to extreme weather and blackouts. They refer to a study conducted by the University of South Australia (UniSA) to the ABCB in 2016[48] which 'found no correlation of star ratings and heatwave performance (or cooling energy) of a home that was already at 6 stars' and that the 'draft elemental measures have shown that NatHERS can encourage a design to include design features (no eaves, dark colours) that worsen heatwave performance'. Notably, the UniSA study recommended that heating and cooling loads be implemented to reduce reliance on heating. This recommendation was addressed by the introduction of the heating and cooling load limits standard in the NCC in 2019. The 2019 standard

[47] Notably, it is expected that the updated climate files will be incorporated in all the new versions of the four NatHERS tools well in advance of the introduction of the new regulation.

[48] https://www.abcb.gov.au/sites/default/files/resources/2020/Does-the-Australian-Nationwide-House-Energy-Rating-Scheme-ensure-heat-resistance.pdf

improves the performance of homes that were designed to perform well in one season, but poorly in another (i.e. high levels of thermal performance in winter, poor performance in summer), and as such, the findings of the UniSA study are no longer applicable to the current version of the NCC (the baseline in the CRIS).

Another submission argues that other feasible options are highly energy efficient – all electric buildings with no gas connection and the net zero option modelled for the Trajectory. In addition, this submission recommends that equipment and solar PV are decoupled in the energy use budget for Class 1 buildings and the thermal performance standard is set to 7.5 stars for Class 2 buildings. This submission also argues that the status quo is not an option as there is a pressing need for decarbonisation.

NASH notes that the options of site- and community-scale solar energy generation are missing in the analysis and that fabric measures have reached their limit (6 stars) and are being pushed way beyond their cost-effectiveness, resulting in diminishing returns. They suggest the following alternative policy options:

— boosting the renewable energy proportion in the electricity grid
— restoring the option of 100 per cent offsets for on-site renewable energy for services
— enforcing efficiency standards for appliances
— 'tweaking' 6 star fabric measures (no further details of what this would entail were provided).

In respect to the cost effectiveness of star rating improvements beyond 6 stars it is important to note that, analysis of the fabric improvements by Tony Isaacs Consulting (TIC) shows that there are cost effective savings beyond 6 stars in at least some climates zones. This analysis is provided in TIC's report titled 'Cost and Benefits of upgrading building fabric from 6 to 7 stars' which is available through the ABCB's website[49].

The LCA proposes that the following alternative options are analysed in the RIS:

— removal of redundant lighting energy efficiency provisions (such as section 3.12.5.5. of NCC 2019)
— simplification of the NCC provisions to simply require at least 95 per cent of all lighting installed be LEDs
— alignment of the lighting energy efficiency provisions with international standards such as 'ISO/CIE 20086:2019 Light and Lighting - Energy Performance of Lighting in Buildings'.

EBAA argues that an additional policy option presenting a well-designed and operated passively-designed house needs to be included in the analysis.[50] It is noted that such houses are the safest and lowest energy option that use little or no energy for heating and cooling, and are resilient and adaptive

[49] https://consultation.abcb.gov.au/engagement/consultation-ris-proposed-ncc-2022-residential/supporting_documents/Costs%20and%20Benefits%20of%20Upgrading%20Building%20Fabric%20from%206%20to%207%20Stars%20Tony%20Isaacs%20Consulting.pdf

[50] As noted above, TIC assessed a sample of specialist passive solar and well-ventilated designs with ideal window orientation which showed cost savings of between 25 per cent and 50 per cent when compared to the typical houses.

to warming climate conditions (as they could provide safe cool refuge space for shelter during storms, cold-snaps, heatwaves and during blackouts or with energy poverty). EBAA argues that increased envelope efficiency, higher star ratings and the embedded preference for the use of mechanical air conditioning as proposed will all increase the use of mechanical air conditioning and embodied energy consumed.

Feedback associated with the policy options analysed in the RIS was referred to the ABCB for consideration. In response to this feedback, the ABCB explored the potential inclusion of a number of alternative policy options in the Decision RIS (noting that policies for existing buildings are outside of the remit of the NCC). The alternative options considered by the ABCB are discussed in more detail in Section 4.2.3.

2.1.5 Disaggregation of impacts

The Victorian Government, ENA, Rebecca Vassarotti MLA, submission ANON-7GZH-JXFC-B and another submission suggest that the impact of the various elements within Option A and B (shell and WoH provisions) should be evaluated separately. Rebecca Vassarotti MLA argues that 'undertaking an assessment of constituent parts of each option may identify additional benefits and new cost-effective options may emerge'.

The Victorian Government and another submission also request that these 'unbundled' results and results for Class 1 and Class 2 buildings are separately reported in the RIS.

In response to feedback provided by submissions, the Decision RIS now also presents results by building class. The impacts of the shell provisions alone are discussed in TIC's report titled 'Cost and Benefits of upgrading building fabric from 6 to 7 stars' which is available through the ABCB's website[51]. The impact of the WoH provisions only cannot be modelled, as the WoH technical modelling conducted for the RIS included the changes to the building fabric.

2.1.6 Impact of climate change

Several stakeholders commented on the impact of climate change. Generally, feedback was provided across two areas:

— the climate data used to model the energy impacts
— the need to build resilient buildings in response to the impacts of climate change.

PCA, ASBEC, GBCA, EEC, EBAA, Renew and the New England Greens argue that the climate data used to model the energy impacts is flawed because it does not account for extreme heat days and does not capture the warming that has occurred over the last decade or so, and that this carries through to unrealistic assumptions regarding energy use demand in hot weather when the grid is under most stress. In particular, it was noted that the CSIRO's updated climate files are not

[51] https://consultation.abcb.gov.au/engagement/consultation-ris-proposed-ncc-2022-residential/supporting_documents/Costs%20and%20Benefits%20of%20Upgrading%20Building%20Fabric%20from%206%20to%207%20Stars%20Tony%20Isaacs%20Consulting.pdf

considered in the modelling. Another submission also argues that the CRIS should factor in the projected changes in climate conditions.

Feedback associated with the climate files used in the technical analysis was referred to the ABCB for consideration. In response to this feedback the ABCB noted that:

— TIC's analysis uses the most up to date climate files for their modelling
— Regarding future climate files, while using this files may be beneficial, the office has not been able to fully explore the impact of such a requirement, from either a technical or cost benefit perspective.[52] Notably, depending on the year chosen for the analysis, the use of future climate files may lead to perverse outcomes as designing for future climate will see a much greater reliance on strategies to reduce heating energy. This would have the effect of underestimating heating requirements in the short term and lead to increased GHG emissions from increased heating energy use. The ABCB has initiated a resilience project that may result in using projected climate data rather than historical data going forward, but this is not being considered for NCC 2022. However, it was noted that Section J and the Class 1 VURB does not prohibit the use of future climate weather files if this is desired.

Submission ANON-7GZH-JXVR-A argues that the CRIS is blind to the consequences of runaway climate change and that there should be consideration of the costs of not implementing net zero now.

PCA, ASBEC, GBCA and EEC argue that resilience should be considered in the design phase of a building, and buildings and their cooling systems should be designed to withstand extreme events such as heatwaves and power outages.

Improving the resilience of buildings to future climate risks is the subject of a separate ABCB project. In response to a recommendation of the *Royal Commission for National Natural Disaster Arrangements* the ABCB is reviewing the adequacy of the NCC to address future extreme weather events and climate risks.

Additional discussion on building resilience is provided in Chapter 9.

2.1.7 Non-market impacts

Household impacts

The inclusion and quantification of non-market household impacts was an issue raised in a number of submissions. The non-market impacts referred to in submissions were numerous, and include:

— health and amenity – these relate to:
  – the improvement in thermal comfort (without the need for air-conditioning) and the health impacts related to these improvements

[52] There are significant challenges associated with this analysis, including (amongst others) the amount of information/scenarios that would need to be considered/analysed (e.g. there are climate files for today, 2030, 2050, 2070, and 2090 at three different levels of warming), determining how future performance should be weighed against performance today, and developing benchmarks for the minimum acceptable performance for each future scenario.

- the reduction in use of gas and wood in the household (and the possibility of transitioning away from gas altogether in some climates) and the resulting improvements in respiratory health as a result of reductions in particulates and noxious gases
- the impact on productivity or fewer sick days as a result of healthier, more comfortable buildings
- negative health impacts of poorer air quality from overly tight building envelope that does not allow proper airflow – especially during heatwaves and during blackouts

— resilience – this relates to passive survivability (e.g. how long can the dwelling provide thermal conditions acceptable to occupants in the event of power outage or against heatwaves)

— decreased resilience – this relates to increasing reliance on equipment (including air conditioners) to make living spaces safe and comfortable which increase the risk from blackouts

— social benefits of having better quality building stock such as the improvement to household budgets.

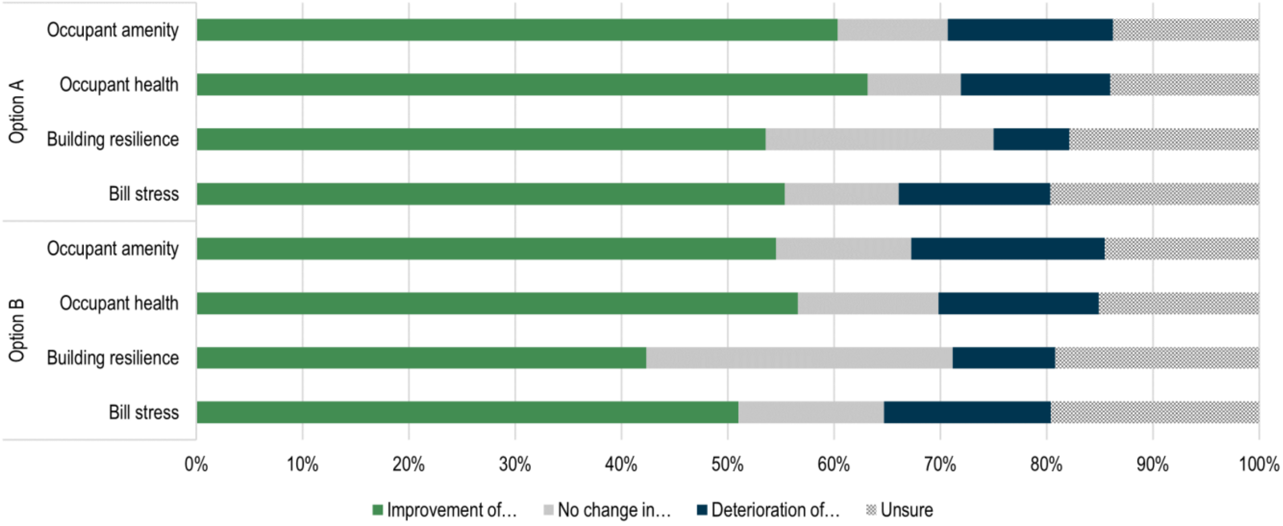
There was a reasonable degree of agreement that the policy options would result in changes in amenity, health, resilience and household budgets. More than half of the submissions that answered the question said there would be an improvement in these aspects as a result of the policy options put forward in the CRIS (see Figure 2.4):

— 71-77 per cent of respondents said that there would be some impact (negative or positive) on occupant amenity and health

— 60-66 per cent of respondents said there would be some impact (negative or positive) on bill stress

— 51-60 per cent of respondents said there would be some impact (positive or negative) on building resilience.

Figure 2.4 Survey responses on non-market household impacts



Note: Responses refer to question 35, Will improvements in the following areas be realised: occupant health, occupant amenity, the resilience of buildings to extreme weather and blackouts, stability of the electricity grid, reduced bill stress, increased GDP and economic stimulus? Chart excludes submissions that did not answer this question.

Source: Citizen Space submission data.

Amenity

Improved thermal control and comfort is certainly a potential impact of the proposed policy options as a result of more comfortable homes. This is discussed further in Chapter 9.

Health

Stakeholder feedback regarding the health impacts of the measures are separable into the direct impacts of the reduction in burning of fossil fuels and biomass; and the indirect, where more energy-efficient houses form a protective (morbidity-preventing) environment against heatwaves and extreme weather. The case for including both of these health impacts is clear, and therefore they will be qualitatively covered in the Decision RIS.

As noted in Chapter 9, at present there is limited available evidence regarding the indirect health benefits of energy efficiency improvements. While there is economic and public health literature on the health effects of heatwaves and extreme weather in general, evidence regarding the quantification of the effects of the built environment on moderating these health impacts by moving from NCC 2019 to the proposed NCC 2022 are lacking. No evidence was provided in submissions sufficient to quantify, model or monetize the impacts; and a review of the literature was also not forthcoming with evidence.

Most of the direct health benefits from the proposed policies will come from reduced domestic gas consumption. Health impacts of domestic gas usage have better sources of information available and have been taken into consideration in the Decision RIS (additional discussion about the methodology used to develop these estimates is provided in Chapter 5).

Firewood burners are also a significant cause of particulate matter and noxious gases. Firewood burners are far less common in new builds than gas heaters. However, they are likely to have a larger effect on human health than gas burners — particularly for poorly maintained wood burners. The approach that has been to estimate avoided health costs for reductions in wood use in the DRIS is outlined in Chapter 5.

Building resilience

Several submissions, such as those from the New England Greens and Renew, comment on the effect of the policy options on improving the resilience of residential building to extreme weather conditions and blackouts. However, none of the submissions reviewed provided specific evidence of the impact of improved energy efficiency on resilience to extreme weather events or climate change that could be used to provide more detailed analysis in the Decision RIS.

There is growing academic literature which has been produced which comment on the relationship between energy efficiency and resilience[53], however the evidence is insufficient to quantify the effect of the difference between NCC 2019 and the proposed NCC 2022 and include in the modelling.

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[53] Aldieri, L., Gatto, A., & Paolo Vinici, C. 2021, *Evaluation of energy resilience and adaptation policies: An energy efficiency analysis*, Energy Policy.

In response to the feedback received, additional discussion on building resilience has been provided in Chapter 9. The benefit of broader societal resilience to climate change has been reflected through assumptions adopted for the cost of carbon, which are discussed further in Chapter 5.

Bill stress

Energy bill stress is directly related to energy use and therefore energy efficiency savings from a dwelling. However, the degree to which a household is affected by bill stress also is moderated by overall household budget, the timing of bills (for example, whether they are due proximate to higher household spending around holiday periods), and a range of other household-specific issues. The energy efficiency savings are reflected in annual savings, which will be realised by households in their lowered quarterly or ongoing energy bills. No specific evidence was provided on *additional* benefits — that is, over and above the proportion annual savings — of avoided bill stress. The issue is briefly discussed in Chapter 9.

Societal

The inclusion and quantification of non-market household impacts was an issue in a number of submissions. The non-market impacts identified in submissions were numerous. Significant impacts highlighted include:

— the benefits of better international standing and better acceptance of Australia/Australian businesses as being proactive about addressing climate change
— the avoided costs of future retrofits as a response to climate change and/or international carbon reduction targets
— climate change more broadly
— that some existing house designs and home preferences are not compatible with 7 star design and that there are additional costs for changing designs
— that the NCC will impose complexity in the management of, and additional costs on, strata for Class 2 properties.

Climate change

The societal cost of climate change — or alternatively the potential quantifiable benefits of avoided climate change – are represented in the Decision RIS through the cost of carbon. Drawing on a social cost of carbon captures some of the impacts of climate change which stakeholders have nominated as being insufficiently incorporated in the CRIS.

The reputational impacts of the policy options are difficult or impossible to fully know, and have not been included in the RIS as a quantifiable or unquantifiable impact.

Redesign costs

Redesign costs are discussed in detail in section 7.1.2.

Strata costs

The survey response from the Strata Community Association (SCA) makes note of the additional cost and complexity of metering and managing energy use in Class 2 buildings. Examples provided include shared spaces, shared meters, off-market energy sources, and more complex embedded networks. However, its response does not provide specific evidence and only applies to Class 2 buildings. Accordingly, these issues have not been included in the RIS as a quantifiable or unquantifiable impact. That said, the point raised by the SCA is relevant for implementation of the proposed NCC 2022 as a possible consideration for including a separate policy option for Class 2.

2.1.8 Unintended consequences

Submissions highlighted the following likely unintended consequences of the proposed regulatory changes.

— Added complexity — HIA notes that the proposed changes would add complexity for design, assessment, approval and application of the NCC provisions, and ultimately compliance challenges.

— Reduced consumer choice — HIA argues that, given the challenges to achieve 7 stars (both for project homes and custom designed houses), many standard house designs would need to be abandoned or may be limited to construction on certain orientations only, resulting in reduced choice for consumers.

— Construction and construction inputs — HIA argues that the proposed changes would have significant impacts on house design and on standard building materials and construction practices and noted that the proposed standards could have significant negative impact on current products in the market. Another submission argues that suppliers to the volume industry are not capable of delivering the products needed to support the proposed change at scale and suggests that the supply chain industries need certainty and to be granted reasonable time to adjust their manufacturing operations in support of the new targets.

— Gas industry viability — HIA noted concerns over the impacts that the proposed changes would have on the future viability of the gas sector.

— Reduced ventilation and increased condensation —the risk of lower ventilation and increased condensation and mould as a result of the proposed changes was raised by several submissions.

— Increased fire risk — HIA and BlueScope Steel suggest that the proposed changes could encourage the use of Expanded polystyrene (EPS), increasing the fire risk of new housing.

— Amenity loss — BlueScope Steel, the LCA and HIA argue that the proposed changes would lead to decreases on building amenity and value, particularly with respect to reductions in window size. These submissions and submissions made by the Australian Glass and Window Association (AGWA), EBAA and NASH argue that the loss in amenity due to smaller windows should be valued. AGWA and HIA provided references to research that highlight the potential negative impacts of reductions in window size and daylight. While these references do not provide sufficient evidence to value the amenity losses from reductions in window size, they provide rich evidence about the importance of daylight and windows. A discussion of the benefits of window and glazing based on the references is provided in Appendix I and additional analysis of the impacts of reduced window size on costs is provided in Section 0.

- Star rate creep — HIA and another submission noted that star rating creep has not been discussed, arguing that over the last decade there have been multiple NatHERS software updates and other changes in the NatHERS protocols that mean that a home that was 6.0 stars in 2011 is unlikely to be 6.0 stars in 2021 (more likely to be 5.5 stars). In this respect, the ABCB notes that these changes to NatHERS have been assessed on their merits through other analysis when the change occurred, and hence are not a relevant consideration of this RIS, other than to note that rating tools require maintenance and refinement over time.
- Negative impacts of PV — HIA argues that the CRIS does not provide a detailed assessment of the following unintended impacts of higher rates of PVs installations:
  - damage due to hail events and clean up and insurance costs for replacement of PVs
  - building fires attributed to PVs on roofs
  - water ingress due to installations and PVs becoming wind driven debris in high wind events.
- Over-regulation — HIA and another five stakeholders noted concerns about the compounded effects of other significant amendments in NCC 2022 beyond the proposed energy efficiency changes. These amendments include:
  - mandatory accessible housing provisions for all new Class 1 and 2 buildings and extensions for Class 1 buildings
  - more stringent condensation management provisions in both Class 1 and 2 buildings
  - more stringent waterproofing provisions for both Class 1 and 2 buildings
  - further fire safety provisions changes and restrictions for Class 2 buildings
  - EV charging future proofing and solar ready zones for Class 2 buildings
  - fixing and flashing requirements for Class 1 buildings
  - a broad range of Australian Standards changes
  - NCC restructuring changes
  - Performance Solutions changes.

  HIA argues that[54]:

  ‘All of these changes add more complexity, stringency increases and ultimately have significant impact on affordability and viability of Class 1 projects. More importantly, each of these changes requires industry to understand, adapt and adopt the changes into their current business operations and their current building designs.

  These changes need to be better rationalised and not looked at in silos as individual reforms. They must be considered as the cumulative package of changes and an assessment of their overall impact must be made for all housing forms before the changes are implemented.’

[54] HIA submission, p. 14.

Many of the unintended consequences highlighted by submissions were already qualitatively discussed in the CRIS, including the impacts on:

- design complexity
- consumer choice and property rights
- building amenity (including potential impacts on amenity of changes in windows and lights)
- ventilation and condensation
- increased fire risk
- issues associated with PV systems.

These impacts are difficult to quantify because they refer to attributes or services that are not bought and sold readily in the market. Therefore, these issues have been discussed further in the Decision RIS in a qualitative manner to reflect the feedback received during consultation.

Where impacts are treated qualitatively, this should not indicate that they are of little value or influence the overall net impacts of the proposal. Non-tangible costs imposed on consumers (for example, through not being able to build the desired house due to regulatory requirements) can be quite important and hence, to the extent possible, the RIS analysis attempted to control for overlooking amenity costs through unbiased orientation and recognition of additional costs imposed by difficult block constraints.

It is also important to note that, in regard to concerns about ventilation and condensation, the ABCB is currently investigating this issue in a separate project to ensure that the changes being proposed do not increase condensation risks. A report produced as part of this project notes that:

> ‘A peer review indicates that the energy efficiency provisions as proposed under Option A and B do not result in increased condensation risks for NCC 2022.[55]’

2.2 Approach to economic analysis

In addition to the issues discussed in the previous section, stakeholders also provided feedback on the approach taken for the economic analysis in the CRIS and on specific inputs and assumptions used in the analysis.

2.2.1 Asymmetry in the treatment of costs and benefits

The importance of symmetry in reporting the costs and benefits of the proposal was raised by various submissions[56]. The key concerns raised by stakeholder in this regard were:

- the exclusion of the benefits related to thermal bridging mitigation measures when the cost of these measures is included

[55] Inhabit 2021, *Interstitial Condensation Assessment*, October.

[56] Including a joint submission by PCA, ASBEC, GBCA and EEC, and submissions by Renew, New England Greens, the ACT Government, the Victorian Government and another submission.

- the use of wholesale electricity prices and network benefits to measure the benefits of energy reductions when households receive the benefits via retail prices
- underestimating benefits by discounting energy network benefits by 70 per cent under Option B and 80 per cent under Option A, assigning no value to the rebound effect and no replacement of equipment, and overestimating costs by assuming learning rates are zero
- the inclusion of full construction costs but the exclusion of reductions in wholesale electricity prices as benefits.

The principle of symmetry is key when estimating the costs and benefits associated with proposed regulations. In response to the feedback received during consultation, the application of this principle to the RIS has been further reviewed. The proposed changes to the methodology in the CRIS in response to the issues noted above (where considered appropriate) are outlined in more detail in Chapter 5.

2.2.2 Cost estimation

Many submissions provided feedback with regards to how the CRIS estimates the different costs associated with the proposed requirements. Broadly, the key areas of feedback were around:

- under/over estimation of costs, particularly in relation to the likely response of industry to the regulations
- increased construction costs due to supply chain disruptions
- the introduction of biases in the cost estimation through choices made on the technical modelling
- the costs associated with difficult and shaded blocks
- learning rates
- industry costs
- differences between modelled and realised costs.

More details about the issues raised by stakeholders across these areas and the way in which these have been addressed in the DRIS are provided in Chapter 5.

2.2.3 Specific inputs and assumptions

Feedback was also provided during consultation about specific inputs and assumptions used in the CRIS. These issues have been addressed in Chapter 5.

3 Statement of the problem

3.1 Identifying the problem

Energy use within residential buildings comes with substantial benefits. Australians heat their homes, use hot water, and cook their food not only for amenity, but also to maintain healthy households.

While the objectives of temperate houses and hot water are clear, the energy use required to achieve these objectives comes at a cost, both to those households and to society.

At the household level, utility bills add to the costs of living and can be a source of financial stress, especially for low-income households. To reduce energy costs, households may reduce their energy use. Adverse health and wellbeing impacts can materialise through the impact of the lower energy use on thermal comfort, indoor air quality and excess humidity, the impact of which is amplified during periods of extreme weather, or through the financial stress of high energy bills.

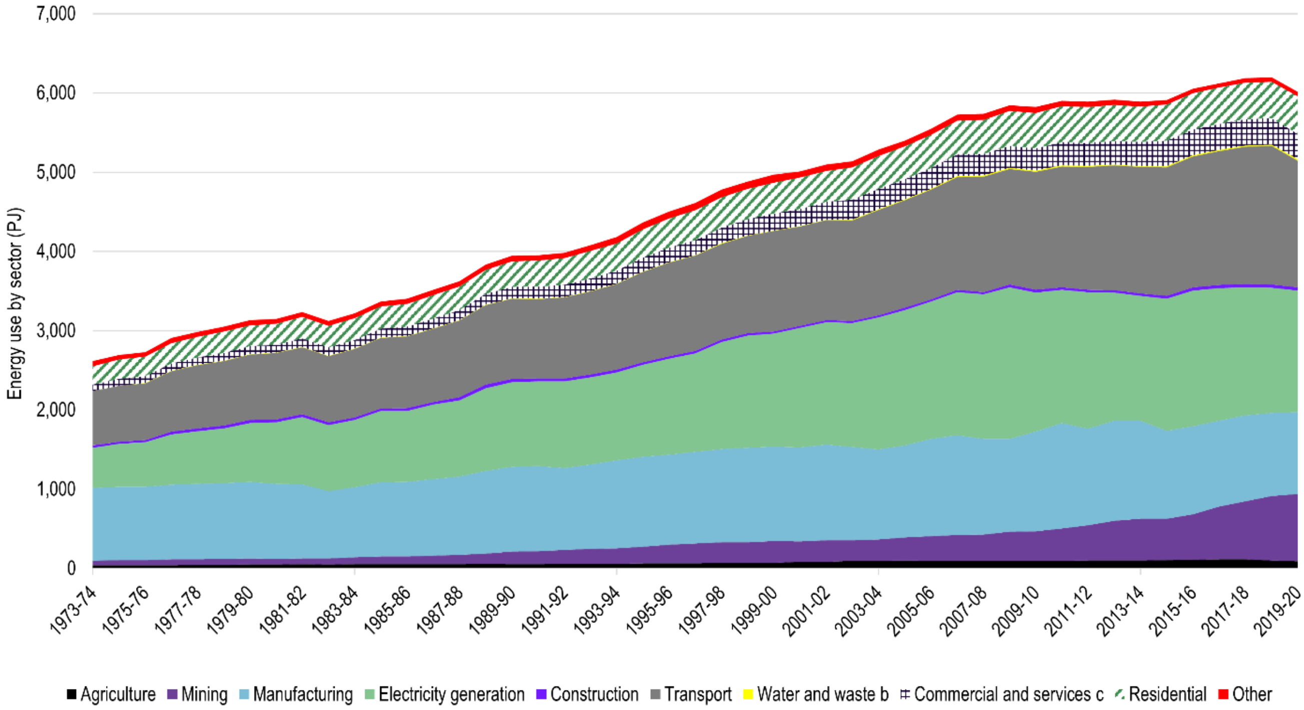
Across society, residential energy use is a key source of energy demand, putting stress on the energy grid so that it is less resilient to extreme weather and blackouts, and generating GHG emissions. Where adverse health and wellbeing impacts materialise at the household level from the high cost of energy, this may have flow on impacts to government spending on health, human services and justice services.

According to the latest Department of Industry, Science, Energy and Resources data, residential buildings are a major source of energy demand and use. It accounts for approximately 8 per cent of Australia's energy use (Figure 3.1). In 2019-20, this was 473.3 petajoules (PJ), about 45 per cent larger than the commercial and service sectors. Since 1974, residential energy use has increased by an average rate of 1.6 per cent per year faster than the rate of population growth, which was 1.3 per cent over the same period. This represents more than a 100 per cent increase in residential sector energy consumption over the period 1973-74 to 2019-20.

Residential energy use is drawn heavily from the burning of fossil fuels. In some years, more than half of residential energy use comes directly from on-site burning of fossil fuels (such as natural gas, LPG) and wood products for space heating, cooking and water heating. The proportion of these direct burning fossil fuels has decreased over time (see Figure 3.2), as has the proportion of fossil fuels used in the electricity grid over time. Across Australia, 50.0 per cent of residential energy use comes from direct burning of fossil fuels. Though this varies across states, with the highest proportion in Victoria, using 75.2 per cent; and the lowest proportion in the Northern Territory, using 15.0 per cent.

Indeed, residential buildings are responsible for around 11 per cent of Australia's emissions and 29 per cent of electricity use.[57]

Figure 3.1 Australian energy use, by sector, 1973-74 to 2019-20

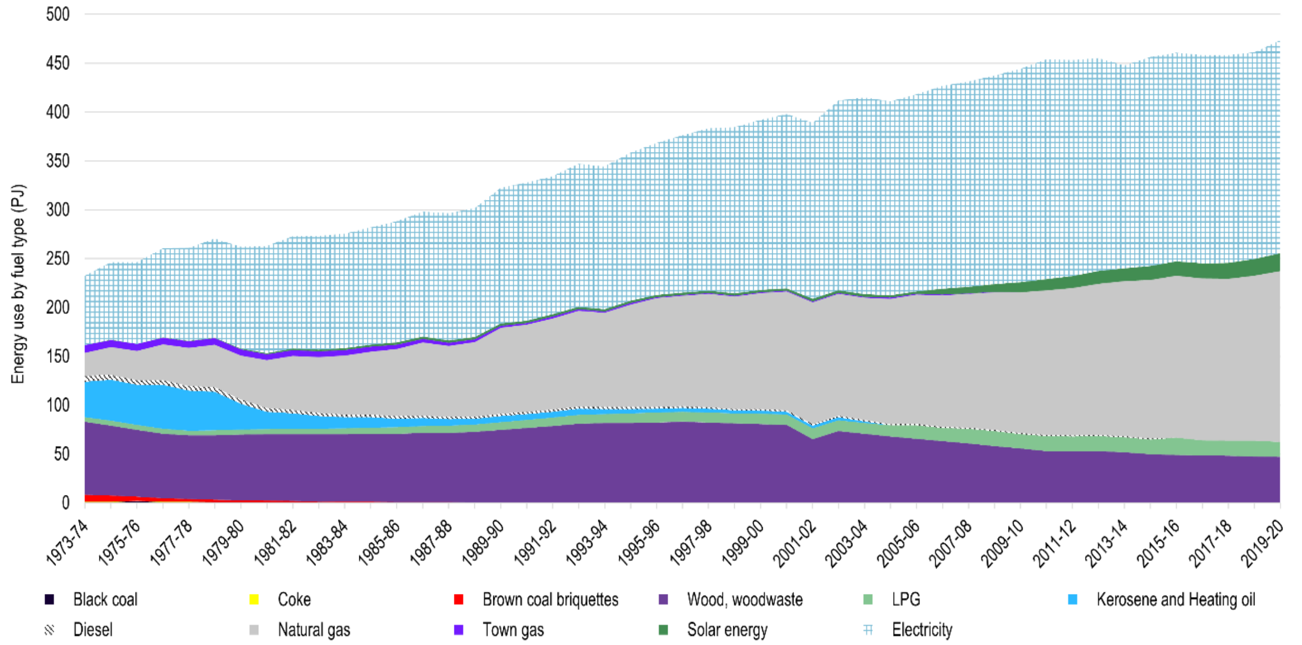


Note: The 'other' category includes consumption of lubricants and greases, bitumen and solvents, as well as energy consumption in the gas production and distribution industries; and energy that is unable to be classified as a result of revisions made to historical series, and discrepancies due to the rounding of totals.

Source: Department of Industry, Science, Energy and Resources 2021, *Australian Energy Statistics*, Table E, September.

[57] COAG Energy Council 2019, Report for Achieving Low Energy Existing Homes, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20Report%20for%20Achieving%20Low%20Energy%20Existing%20Homes_1.pdf, accessed 28 September 2020.

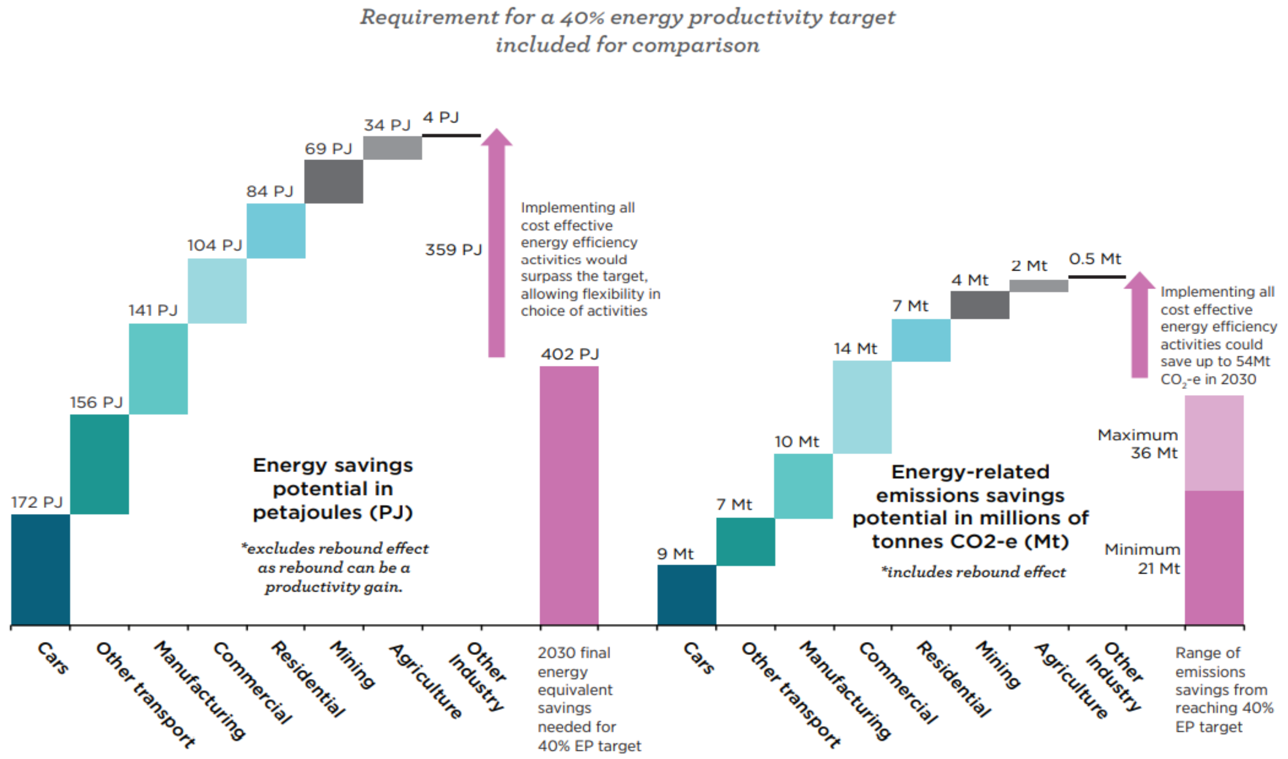
Figure 3.2 Residential energy use, by fuel type, 1973-74 to 2019-20



Source: Department of Industry, Science, Energy and Resources 2021, Australian Energy Statistics, Table F, September.

While Australia has made considerable progress in the energy performance of residential buildings, there is still opportunity to implement actions that could further reduce the energy consumption of the sector. Indeed, the NEPP identified that residential buildings can contribute significantly to reach the target of improving Australia's energy productivity by 40 per cent between 2015 and 2030 by reducing Australia's energy use by 84 PJ (see Figure 3.3).

Figure 3.3 Energy productivity opportunities identified in the NEPP



Source: COAG Energy Council 2015, National Energy Productivity Plan 2015-2030.

There are various barriers that inhibit the capture of energy efficiency opportunities in the residential sector. Some of these barriers can be classed as market failures (and hence warrant policy intervention) and others are not. These barriers have been studied extensively in the literature for many years.

The Trajectory identified the following market failures that inhibit the ability of households to invest in energy efficiency measures within the residential sector: [58]

— **Informational problems** — these refer to a lack of awareness and information, particularly a lack of clear, reliable and comparable information on the energy performance of homes and of the benefits of investing in energy efficiency measures, that can be used by householders to make decisions about home improvements, and by buyers and renters to factor energy efficiency and comfort considerations into their purchasing or renting decisions. When buyers or sellers do not have perfect information about available opportunities, transactions that are mutually beneficial may not take place and markets may not deliver economically efficient outcomes.

— **Split incentives** — where the parties engaged in a contract have different goals and different levels of information. This is a form of the principal-agent problem, where owners do not share the objectives of their renters who pay rental to access properties. In the context of energy efficiency for existing buildings, this refers to a situation in which energy bills and capital rights

[58] Council of Australian Governments (COAG) Energy Council 2018, *Report for Achieving Low Energy Homes*, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Report%20for%20Achieving%20Low%20Energy%20Homes.pdf, accessed 16 September 2020.

are misaligned between economic actors. In the context of new buildings, this could relate to where builders or designers do not share the objectives of those purchasing new homes.

— **Capital constraints** — access to capital is critical to supporting energy efficiency investments. Capital constraints are particularly relevant to energy efficiency investments as these require up-front capital or financing, but the benefits of the investments (lower energy costs) accrue over time and are often misaligned with the financing period.

Other market failures associated with high energy use and lower uptake of cost effective energy efficiency investments in the residential sector include:

— **Negative externalities associated with energy consumption** — unpriced negative externalities associated with energy consumption result in energy prices that do not fully reflect the cost of consuming energy (which includes the cost of GHG emissions and externalities associated with peak demand). This results in higher energy consumption than socially optimal and in lower investment in energy efficiency measures.

— **Incomplete markets** — residential properties are an extremely heterogenous market. Differences in location, build, design, and cost abound between residential premises. Because the characteristics of residential houses are bundled, the purchasers of new buildings may subrogate preferences for energy efficient houses for other preferences, such as the number of rooms, which result in under-consumption of energy efficiencies (or other characteristics).

— **Market rigidities** — residential properties are extremely lumpy purchases for most households – for whom it will likely be the largest single asset. In addition, it is relatively expensive to transact in houses for both purchasers and renters, and building new homes is a time- and capital-intensive process. These market rigidities mean that it takes longer for the market to meet demands for improved energy efficiency.

3.2 The policy response

Commonwealth and state governments have introduced a number of measures to address the market failures outlined above, reduce energy use and improve the energy efficiency of the residential sector. These include:

— the minimum energy efficiency requirements for new residential in the NCC (which have been in place since 2003 for houses, since 2005 for multi-residential buildings and since 2006 for commercial buildings)

— the Equipment Energy Efficiency (E3) program, and the Greenhouse and Energy Minimum Standards (GEMS)

— a number of energy efficiency programs, including obligations, schemes, grants and rebates to help households improve aspects of their energy use or efficiency

— a range of policies and initiative implemented by state and territory governments to improve existing buildings (see Box 3.1)

— the NEPP and the Trajectory (a further policy development under NEPP), which include multiple actions to improve the energy efficiency of Australian buildings

— the Australian Government Energy Policy Blueprint, which sets out clear objectives and detailed policies to ensure a better energy future for Australia.

Box 3.1 State and territory initiatives

The Trajectory acknowledges a range of state and territory government initiatives and policies which support energy efficiency in existing residential buildings. The list includes, but is not limited to:

Australian Capital Territory

— NEPP Measure 2.1: The ACT Energy Efficiency Improvement Scheme has new residential heating “heat pump” upgrade activities.

— NEPP Measure 4: Following the successful ACT Public Housing trial program in 2017-2018 to upgrade heating and hot water systems, a new ACT (Public) Housing program will upgrade and replace heating systems with high efficiency reverse cycle air conditioning heat pumps, with demand response capability, over the next 5 years in a percentage of ACT’s public housing.

— NEPP Measure 4: The Actsmart - Low Income Solar program has had strong take up, while the Actsmart low-income household programs continue to deliver advice on practical ways for low-income households in the ACT to reduce energy.

— NEPP Measure 11: The ACT Government has begun a three-year Innovative Financing project to reduce barriers to utilising smart financing for energy efficiency upgrades in the ACT.

— NEPP Measure 13: The ACT’s Next Generation Energy Storage program continues to have good take up and is driving investment in “smart batteries” across the ACT. This has led to an energy distributor partnering with the ACT Government and 400 households, who now own “smart” batteries mainly through this ACT program, to participate in a city-wide virtual battery demand response trial.

— NEPP Measure 31: The first ACT “gas free” all electric, solar PV new residential suburb trial has been announced.

— The ACT is also reviewing its existing residential energy efficiency disclosure scheme and investigating options for improving the energy efficiency of rental accommodation in the territory.

New South Wales

The NSW Government Climate Change Fund is funding the following initiatives:

— $15 million for up to 3,400 low-income households opting to receive a 2.5 kW solar power system if they forgo their low-income household rebate.

— $24.5 million for more than 20,000 low-income renters to upgrade lighting, heating and hot water systems.

— $50.2 million for up to 16,500 dwellings in community, public and Aboriginal housing to upgrade items such as heating, cooling, hot water, lighting, insulation, sealing and solar PV; up to 4,500 energy hardship customers to receive solar PV systems and improve energy use knowledge; and at least 23,000 households to replace old inefficient fridges and TVs with new energy efficient models.

— $30 million for up to 140,000 households to upgrade fixed appliances such as lights or heaters.

South Australia

- Retailer Energy Efficiency Scheme (REES): an obligation on energy retailers to provide energy efficiency activities. This scheme is trialling the Victorian Residential Efficiency Scorecard as part of the REES low-income audits targets.
- Household Storage Subsidy Scheme: $100 million will support the installation of approximately 40,000 energy storage systems in South Australian homes, assisting customers to access the benefits of battery storage technology.

Tasmania

- The $40 million Tasmanian Energy Efficiency Loan Scheme provides no-interest-loans of up to $10,000 for households and small businesses to purchase energy efficient equipment and appliances.
- The $750,000 On-farm Energy Audit and Capital Grant Program provides up to $20,000 for farmers to undertake audits of stationary energy uses and/or irrigation systems and to co-fund energy efficient capital upgrades.
- A business and government energy efficiency audit program to assist small and medium sized businesses and government agencies better understand their energy use and access funding support for capital upgrades.

Victoria

- The Victorian Energy Upgrades program provides households (and businesses) with access to discounts for a range of energy efficient products. The program works by setting a state-wide target on energy retailers for energy savings that results in the creation of tradeable certificates for a range of energy-efficient products and services being made available to homes and businesses at a discount.
- Through the Solar Homes Program, 778,500 rebates are available over ten years to support eligible households to install solar photovoltaic panels, solar or heat pump hot water systems, or solar batteries on their home. The program is helping households reduce the upfront cost of purchasing solar and save on their energy bills, while also reducing emissions.
- $16.9 million has been invested towards a number of programs to retrofit the homes of 3,300 low-income households. One program is Healthy Homes that provides free home energy upgrades to up to 1000 vulnerable Victorians who live with complex healthcare needs, and have low incomes, in Melbourne’s western suburbs and the Goulburn Valley.
- The Victorian Residential Efficiency Scorecard is a voluntary home efficiency rating tool. Householders who are interested in understanding more about the energy performance of their home can contact a private provider and arrange for a rating assessment. The provider collects data on site and calculates a star rating. With the help of the Scorecard tool, the assessor can also offer suggestions for cost effective energy improvements to the home.

Queensland

At the time of the Trajectory, Queensland had a number of programs targeting low-income householders, including:

— Solar for Renters: $4 million program that provided rebates to landlords to install solar PV systems on their rental properties.

— Energy Savvy Families: Provided digital meters to eligible low-income families in regional Queensland, together with energy efficiency information to help them gain a greater understanding of when and how they use their electricity. They invested a further $4 million to extend the program to a further 4000 low-income households.

— Solar for public housing trial: Indigenous Community Lockhart River benefited from a 200-kilowatt rooftop solar farm with a battery storage system which was integrated into the diesel-powered network. The rooftop solar farm provided 10 per cent of the community's electricity supply and aimed to offset thousands of litres of diesel fuel usage with cheaper solar electricity. The Cairns and Rockhampton Sunny Savers trial had over 800 public housing tenants signed up to benefit from a solar power purchase agreement to access cheaper solar electricity. Participants in the Sunny Savers trial can save up to $250 on their annual electricity bill. The Logan part of the trail was expected to the rolled out in 2020.

— Interest Free Loans for Solar and Storage: This program included up to 3500 solar assistance packages offering an interest free loan of up to $4500 over seven years to eligible households. Eligible households must have spent over $1000 in the last six months on electricity, and be receiving Family Tax Benefit B.

Source: COAG Energy Council, Report for Achieving Lower Energy Homes, 2018.

3.3 Need for further government intervention

As outlined above, the minimum energy efficiency requirements for residential buildings in the NCC have been in operation since 2003 for houses and since 2005 for apartments. In 2010 these requirements were increased to 6 stars and have remained at this stringency level for 10 years. The case for a further stringency increase in these requirements is set out in the sections below.

3.3.1 Policy developments

As discussed in previous sections, a number of recent policy developments are driving the case to increase stringency of the minimum energy efficiency requirements in the NCC for residential buildings. These include:

— the Paris Agreement, under which Australia set an economy-wide target to reduce GHG emissions by 26 to 28 per cent on 2005 levels by 2030 (a target that it is aiming to overachieve) and the commitment by all Australian States and Territories to achieve net zero emissions by 2050 (or earlier). These commitments have been made to mitigate the impacts of human-induced climate change, which is affecting many weather and climate extremes across the globe.[59] As noted by CIE, the domestic challenge is to achieve these targets at least cost and energy efficiency is often cited as a low (or in some cases negative) cost approach to achieving GHG abatement[60]

— the Victorian Government's commitment to improve the thermal performance of new residential buildings from 6 stars to 7 stars and strengthen energy performance standards for fixed appliances such as heating and cooling, hot water systems and lighting[61]
— the NEPP, which sets a target of improving Australia's energy productivity by 40 per cent by 2030 on 2015 levels and includes a number of measures to reduce the energy use of residential buildings. Specifically, Measure 31 of the NEPP recommends the consideration of changes to the NCC to achieve better energy efficiency outcomes for Australia's buildings
— the Trajectory (a further policy development under NEPP), which sets a plan towards zero energy (and carbon) ready buildings for Australia and identifies opportunities for the building sector. The Trajectory suggests a number of changes to increase the stringency of energy efficiency provisions in the NCC for residential buildings.

3.3.2 Evidence on cost effective energy efficiency opportunities for new residential buildings

A number of studies have identified cost effective energy efficiency opportunities relative to the current minimum standards for residential buildings in the NCC.

In 2012, the former Department of Climate Change and Energy Efficiency (DCCEE) commissioned a report to identify cost effective savings in the energy consumption of new buildings (both residential and commercial) that could be achieved in Australia by 2020 relative to buildings compliant with the 2010 version of the Building Code of Australia (BCA).[62]

The report was updated in 2016 to help inform potential future policy settings. The updated report found that there are significant cost effective opportunities for energy savings in new residential buildings – as high as 49 per cent Australia-wide, although this varies by jurisdiction (see Table 3.1). Depending on assumptions made about industry learning rates, the report found that by 2020, energy savings ranging from 8 per cent to 49 per cent could be achieved across Australia. This equates to

[59] Intergovernmental Panel on Climate Change 2021, *Sixth Assessment Report*, 9 August

[60] Centre for International Economics (CIE) 2018, *Decision Regulation Impact Statement, Energy Efficiency of Commercial Buildings,* prepared for the Australian Building Codes Board, 13 November.

[61] The Victorian Government's Climate Change Strategy (available at https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0025/522169/Victorian-Climate-Change-Strategy-Accessible.pdf) and Energy Sector Emissions Reduction Pledge (https://www.energy.vic.gov.au/energy-sector-emissions-reduction-pledge)

[62] Pitt&sherry 2012, *Pathway to 2020 for Increased Stringency in New Building Energy Efficiency Standards: Benefit Cost Analysis*, prepared for the Department of Climate Change and Energy Efficiency, January, https://www.energy.gov.au/sites/default/files/pathway-2020-increase-stringency-new-building-energy-efficiency-standards-benefit-cost-analysis-residential-update-2016.pdf, accessed 29 September 2020.

star ratings potentially up to 8 stars for Class 1 dwellings and up to 9 stars for Class 2 dwellings, depending on the state/territory.[63]

Table 3.1 Percentage of energy savings identified by pitt&sherry that could be achieved cost effectively for residential buildings in 2020 (BCR = 1) relative to the 2010 version of the Building Code of Australia

Learning rate	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australian weighted average
0%	9%	3%	7%	11%	18%	14%	3%	7%	8%
3% p.a. for 10 years [a]	19%	4%	7%	11%	32%	17%	9%	11%	13%
100% after 7 years [b]	44%	56%	49%	50%	47%	53%	41%	55%	49%

[a] Incremental cost falls to zero after 7 years.

[b] 70 per cent of the incremental costs remain after 10 years.

[c] The shadow price of carbon begins at $12.25/t CO2-e in 2015 and increases annually based on inflation (that is, is held constant in real terms).

Note: The benefit cost analysis assumes that performance requirements are introduced in 2019-20 and apply to a cohort of buildings constructed between FY2020 – FY2024 and uses a 7 per cent discount rate. Cost effective levels of energy savings are calculated on a breakeven basis (benefit-cost ratio or BCR of 1).

Source: pitt&sherry 2016, Pathway to 2020 for Increased Stringency in New Building Energy Efficiency Standards: Benefit Cost Analysis: 2016 Update for Residential Buildings, prepared for the Department of Industry, Innovation and Science, May.

In 2018 modelling was undertaken by AECOM to support the Trajectory for Low Energy Homes 2018 report. This modelling showed the impacts of increasing the energy performance of a number of model houses and apartment blocks through adjusting thermal performance and equipment (heating, cooling and hot water) features. The capital costs and the energy bills savings for households and apartment occupants were estimated to analyse the cost effectiveness for households from the upgrades.

The results of a scenario increasing NatHERS star ratings as outlined in Table 3.2[64], and upgrading equipment[65] across different regions in Australia (adjusting the thermal performance to each location to recognise that temperate climates generally offer lower energy savings and longer payback periods for households), are presented in Table 3.3.

[63] Pitt&sherry 2016, *Pathway to 2020 for Increased Stringency in New Building Energy Efficiency Standards: Benefit Cost Analysis: 2016 Update for Residential Buildings*, prepared for the Department of Industry, Innovation and Science, May, https://www.nathers.gov.au/sites/default/files/Pathways%2520update%2520report%2520-%2520final.pdf, accessed 29 September 2020.

[64] To achieve higher star ratings, Class 1 dwellings were generally upgraded with additional insulation and/or improved windows, either low-e or double glazing as appropriate for the climate. Class 2 SOUs were generally upgraded with additional insulation and/or improved windows, either low-e or double glazing as appropriate for the climate.

[65] Appliances were upgraded with a total of 10kW worth of 4 star split system air conditioners and heat pump hot water. Modelling assumed a fixed rate for building sealing and energy usage for lighting, cooking and plugged loads across all Class 1 scenarios.

Table 3.2 Star rating increases applied by AECOM Trajectory analysis in a selection of locations

Capital city	NCC Climate Zone	Class 1 – Houses		Class 2 – Apartments	
		Base case star rating	New star rating	Base case star rating	New star rating
Darwin	1	5.4	6.5	6.0	6.5
Brisbane	2	4.6	5.2	5.0	5.5
Sydney	5	5.5	6.5	5.9	6.4
Adelaide	5	6.1	6.6	6.1	6.6
Perth	5	6.2	6.7	6.4	6.9
Melbourne	6	6.3	7.0	6.2	6.7
Canberra	7	6.5	7.1	6.6	7.1
Hobart	7	6.2	6.7	6.5	7.0

Source: Council of Australian Governments (COAG) Energy Council 2018, Report for Achieving Low Energy Homes.

As shown in Table 3.3, the AECOM analysis found that increased thermal performance and upgraded equipment for new buildings results in a positive net present value at a national level both for houses and apartments separately and combined (although it has mixed results at the jurisdictional level when the two classifications are separately analysed).

Table 3.3 Net Present Value (NPV) to 2050 from the tailored climate analysis, with electric upgrades only

	Class 1 – Houses		Class 2 – Apartments		Combined Class 1 and 2	
	$ million	BCR	$ million	BCR	$ million	BCR
NSW	-$45.8	0.98	$40.6	1.78	-$5.23	1.00
VIC	$42.8	1.02	$109.3	4.20	$152.10	1.08
QLD	$450.4	1.21	-$17.0	0.86	$433.36	1.19
SA	$50.4	1.10	Excluded [a]	Excluded [a]	$50.42	1.10
WA	$797.4	1.85	-$50.3	0.34	$747.06	1.74
TAS	$1.1	1.01	$2.6	5.5	$3.68	1.02
NT	$111.4	2.53	$9.2	5.41	$120.60	2.61
ACT	$239.3	8.29	$3.5	1.99	$242.79	7.68
Australia	$1,647.0	1.22	$97.8	1.34	$1,744.78	1.22

[a] While energy loads for SA were modelled for the purposes of comparing with other locations, assessing potential net benefits was excluded from the analysis.

Note: Results calculated using a 7 per cent discount rate. BCR = benefit cost ratio

Source: Council of Australian Governments (COAG) Energy Council 2018, Report for Achieving Low Energy Homes.

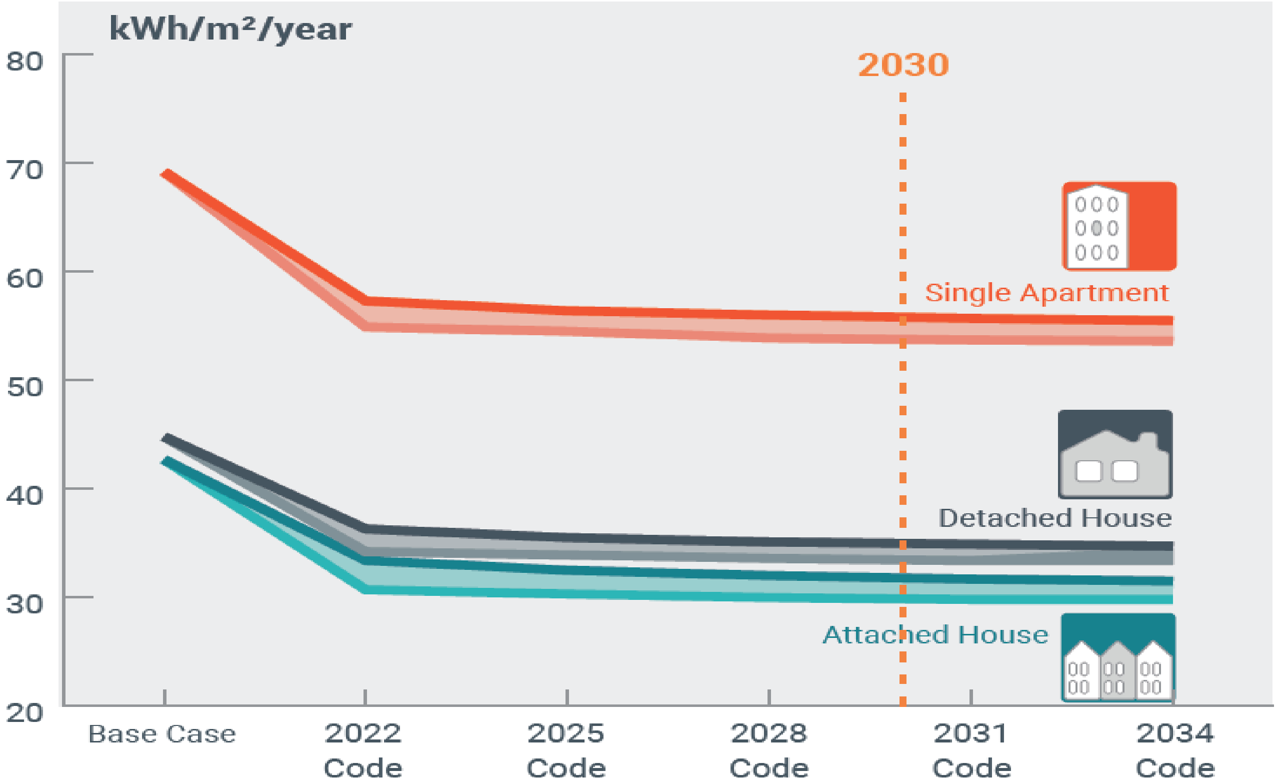
While the Trajectory modelling provided the basis for the options analysed in this RIS, the results from the modelling for the Trajectory are different to those for this RIS as the modelling was undertaken for a different purpose. The key differences between the two sets of modelling include:

- **Focus of the analysis –** the Trajectory is focused on the impacts at a household level while the RIS is focused on the impacts at the societal level, with distributional analysis to illustrate the impact at a household level.
- **Value of energy savings** – as the Trajectory modelling is at a household level, the energy savings are valued at the retail energy prices as at 2017, while the energy savings at the societal level modelling in this RIS are valued based on the (lower) avoided costs. The retail electricity prices in some jurisdictions were significantly higher in 2017 than they are currently.
- **Timeframes of the analysis** – the Trajectory includes the costs and benefits associated with new buildings built to 2050, while the RIS modelling considers the costs and benefits associated with new buildings built over a ten year period only (see Section 5.1.1).
- **Impact of policy –** the Trajectory modelling is based on increasing the minimum standard of the thermal shell by one star from the current application of the NCC in each jurisdiction with electric updates only, while the RIS is based on increasing the minimum standard of the thermal shell from 6 stars to 7 stars taking into consideration the current level of over-compliance and using both electric and gas equipment.
- **Costs and benefits** – the modelling for RIS includes costs that are not included in the Trajectory modelling and, based on more recent research and data, assumes that equipment in the baseline is more efficient (with thus lower potential energy savings).

As a result, the modelling for the Trajectory is not directly comparable with the modelling for this RIS.

ASBEC's 2018 *Build to Perform* report modelled the costs and benefits of two energy efficiency targets for residential buildings in the NCC (one conservative scenario and one scenario with accelerated deployment, see Figure 3.4) and the potential for net energy performance through on-site renewables (solar PV) on eight different building archetypes across four climate zones. The analysis assessed upfront costs associated with improvements, as well as benefits from reduced energy bills, downsizing of heating, cooling and ventilation equipment, and reduced network costs. This report assumes no new gas connections for residential buildings in the accelerated deployment scenarios.

Figure 3.4 Proposed energy targets for the NCC, under conservative (darker line) and accelerated deployment (lighter line) scenarios



Note: Summary trajectories are averaged across all climate zones.
Source: Australian Sustainable Built Environment Council (ASBEC) 2018, Built to Perform, an industry led pathway to a zero carbon ready building code, July

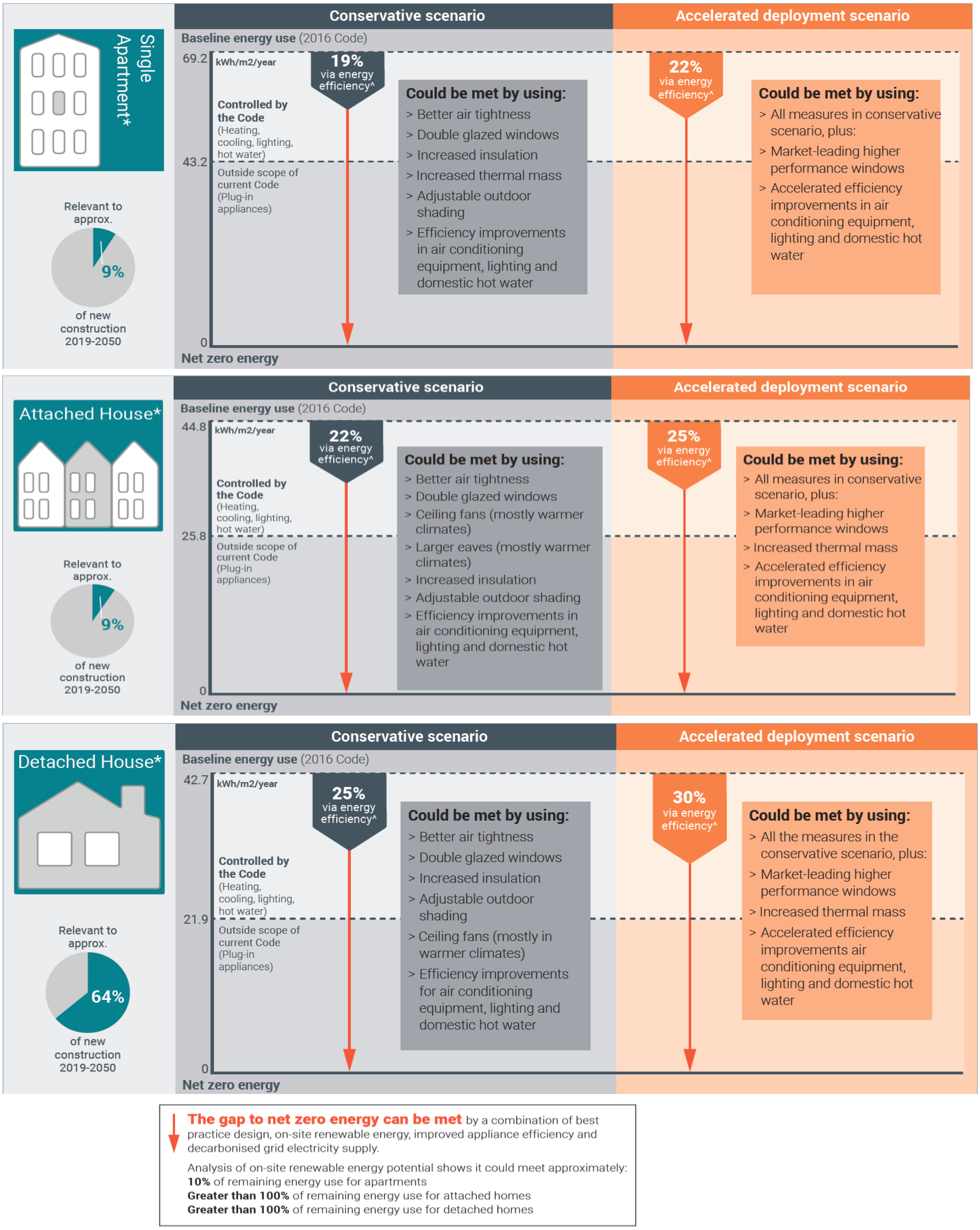
ASBEC's report found that (see Figure 3.5):

— strengthening the energy efficiency requirements of the NCC could cost effectively deliver between 19 and 25 per cent of the energy savings required to achieve net zero energy in new residential buildings by 2030, compared with a baseline that complies with the DTS requirements of the NCC 2016

— under the accelerated deployment scenarios, changes to the NCC energy efficiency requirements could deliver 22 to 30 per cent of the required energy savings to achieve net zero energy in new residential buildings by 2030.

The persistence of this energy efficiency gap (the difference between potential and actual energy efficiency in buildings) and the fact that voluntary approaches have had mixed results to date support the need for government intervention. Section 4.2 in the following chapter discusses why quasi-regulatory approaches are not a workable solution for this problem.

Figure 3.5 Potential 2030 energy targets for residential buildings based on cost efficient measures



* Data presented here is an average for this building archetype across the modelled climate zones (2, 5, 6 and 7) for the 2028 Code
^ Percentage reduction is a proportion of whole building energy (or in the case of the apartment, whole-dwelling energy excluding central services), including energy that is currently not in the scope of the Code and needs to be addressed by measures outside the Code

Source: Australian Sustainable Built Environment Council (ASBEC) 2018, Built to Perform, an industry led pathway to a zero carbon ready building code, July.

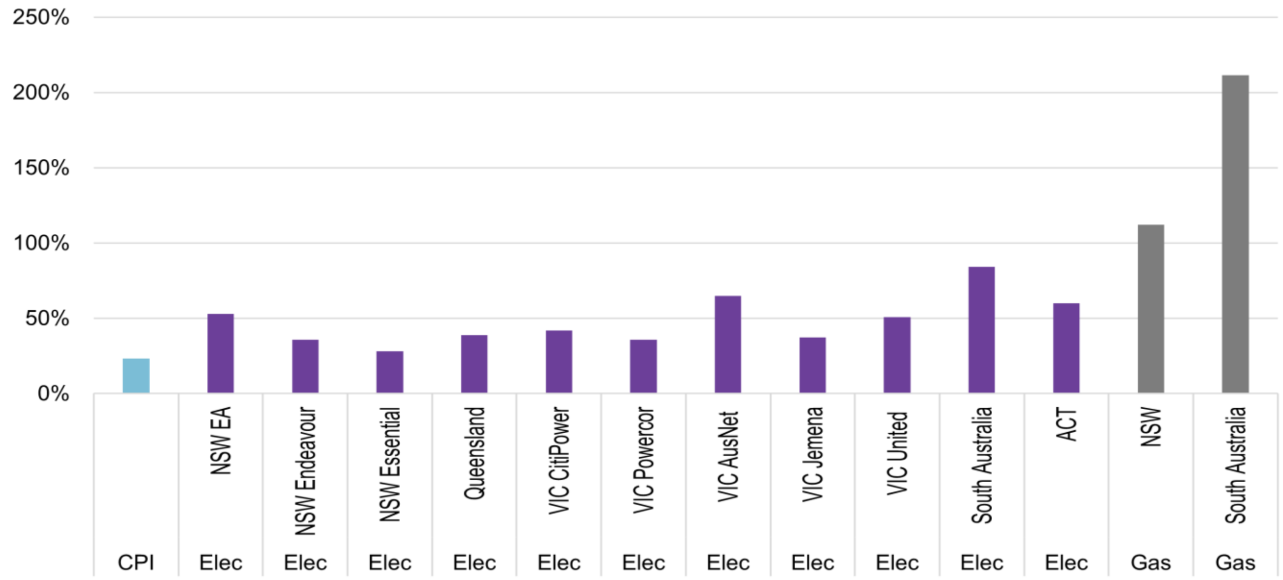
3.3.3 Market developments

Since the last increase to the energy efficiency requirements in the NCC for residential buildings 11 years ago, there have been various market developments which have resulted in lower net costs for energy efficiency measures. These developments include the following:

— **Significant increases in energy prices** – as illustrated in Figure 3.6, according to the Australian Energy Regulator's State of the Energy Market reports, electricity and gas prices have increased above CPI over the 2010 to 2020 period. While CPI has increased by 23 per cent over this period[66]:
  - retail electricity prices have increased from 28 per cent in regional NSW to 84 per cent in South Australia
  - retail gas prices have increased by over 100 per cent in NSW and over 200 per cent in South Australia

  At the time of writing this RIS, there is significant upward pressure on retail energy prices with the ongoing conflict in Ukraine, which has led to significant pressure on coal and gas prices globally; extreme weather which has affected coal supplies (floods in NSW and Queensland) and demand for energy (an early and prolonged cold weather snap); unplanned outages of multiple generators; and slowing investment in new capacity.[67]

Figure 3.6 Increases in electricity and gas prices, 2010 to 2020



Note: The comparison is based on the movement in standing offer prices as these were the prices in the 2010 and 2011 reports. The prices are provided for the jurisdictions included in the Australian Energy Regulator's 2010 and 2011 reports for which the annual consumption on which the annual bills were calculated was provided in the 2020 report.

Source: ACIL Allen analysis based on Australian Energy Regulator's State of the Energy Market reports for 2010, 2011 and 2020

[66] Weighted average of eight capital cities from December 2009 to December 2019

[67] Australian Energy Regulator 2022, Default market offer prices 2022-23, Final determination, May.

- **Decreases in the cost of energy efficient technologies** — improvements in technology and falling prices have made energy efficiency measures more cost effective. For instance:
  - The price of LED lights has fallen significantly over the years. In 2018 LEDinside[68] reported that the global average price of 60-Watt equivalent LED products dropped from around USD$45-50 in January 2011 to below USD$10 by July 2018.[69] The 2018 RIS assessing increased stringency to the energy efficiency provisions for commercial buildings in the NCC also noted that 'the lighting industry reported that the cost of energy efficient light emitting diode (LED) lighting has fallen by more than 50 per cent in recent years'.[70]
  - Glazing industry representatives consulted for the 2018 RIS assessing increased stringency to the energy efficiency provisions for commercial buildings reported significant reductions in the cost of energy efficient glazing in the Australian market over recent years.[71] Similar feedback was received during the consultation process for this RIS.
  - In the last ten years, rooftop solar costs have fallen from above $2.50 per Watt to around $1.00 per Watt or less.[72]

As a result of the above changes, the cost effectiveness of a range of energy efficiency opportunities have expanded significantly. Increasing the stringency of the energy efficiency requirements in the NCC for residential buildings is an opportunity to capture some of these opportunities.

3.3.4 Energy is a significant cost for some households

At the household-level energy use is a major expense, costing each household approximately $43 per week on average, of largely unavoidable costs.[73] According to the Australian Household Expenditure Survey, the cost of domestic fuel and power increased by 28.5 per cent in nominal terms between 2009-10 and 2015-16. Between 2008 and 2018, the proportion of disposable income devoted to energy use has increased for all groups. This category includes both electricity, and heating fuels like gas and wood. These costs vary significantly between urban areas and rural areas, and between states. For instance, in 2015-16, households in Brisbane spent as low as $35.20 on energy, while those in Darwin spent as much as $49.54. Across Australia this varies between 2.3 and 3.7 per cent of total weekly household spending.

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[68] LEDinside is the LED division of TrendForce (a global provider of market intelligence on the technology industries) which provides intelligence on the global LED industry.

[69] LEDinside 2018, Global LED Lighting Products Price Trend, https://www.ledinside.com/news/2018/8/global_led_lighting_products_price_trend, accessed 28 September 2020.

[70] Centre for International Economics (CIE) 2018, *Decision Regulation Impact Statement, Energy Efficiency of Commercial Buildings,* prepared for the Australian Building Codes Board, 13 November, p.29.

[71] Ibid.

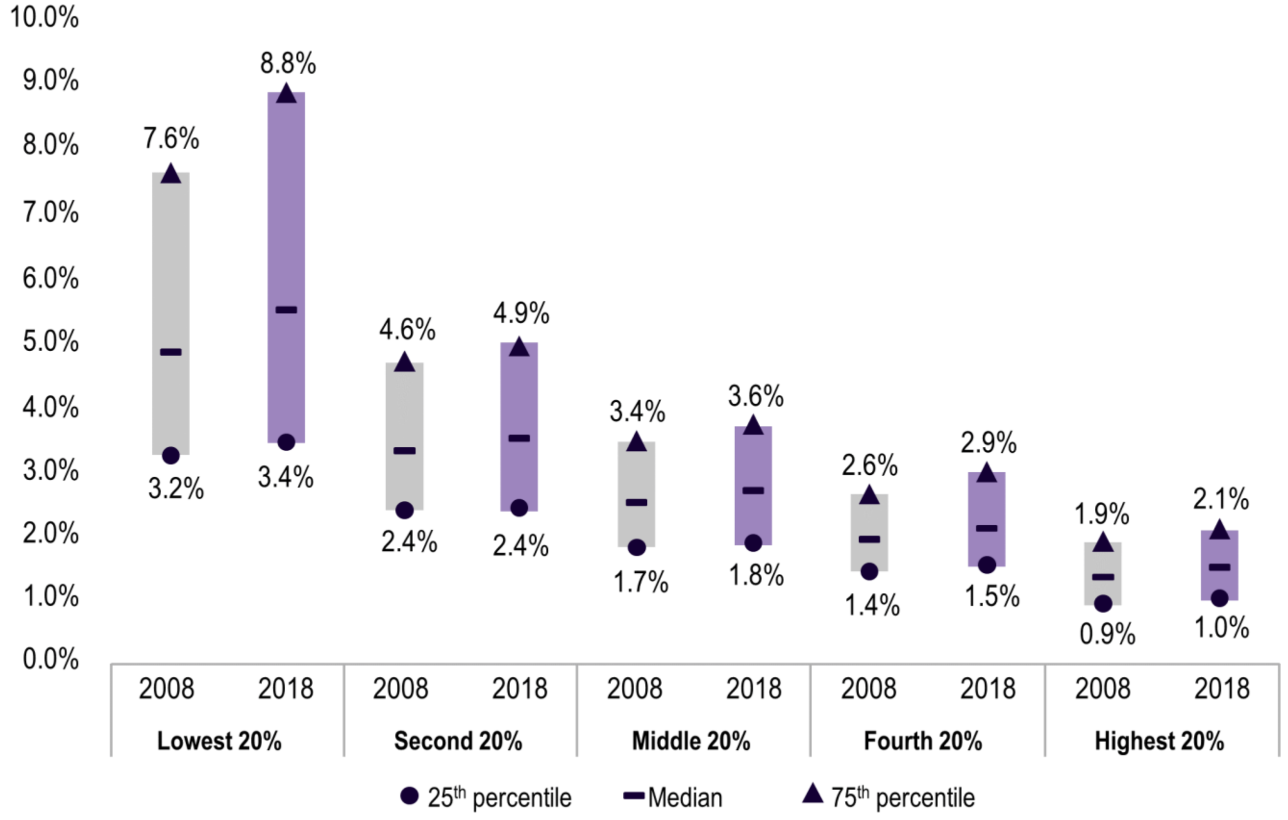
[72] Solar Choice 2020, https://www.solarchoice.net.au/.

[73] Australian Bureau of Statistics (ABS) 2016, Household Expenditure Survey, Household expenditure, 1984 to 2015-16, https://www.abs.gov.au/statistics/economy/finance/household-expenditure-survey-australia-summary-results/latest-release, accessed 29 September 2020.

The energy bill burden is even more pronounced for low-income households, where energy costs can make up a larger portion of the household's income. Of those households in the lowest income quintile, a quarter were spending more than 8.8 per cent of their income on energy. And of those on Jobseeker and similar allowances, a quarter were spending more than 9.7 per cent of their income on energy use.[74] Rising energy costs have exacerbated this trend, with cost increases proportionally affecting lowest-income households by a larger degree (see Figure 3.7).

Increasing the energy efficiency standards for new residential dwellings would provide the greatest level of support for the lowest-income households that spend a higher proportion of income on their energy use, thus leading to a more equitable outcome.

Figure 3.7 Percentile distribution for electricity and gas expenditure as a percentage of income by disposable income quintiles



Source: Ben Phillips, Trends in household energy expenditure (commissioned and prepared for by ACOSS and the Brotherhood of St Laurence), ANU Centre for Social Research Methods, 2018, accessible from HTTPS://WWW.ACOSS.ORG.AU/WP-CONTENT/UPLOADS/2018/10/ENERGY-STRESSED-IN-AUSTRALIA.PDF.

[74] Ben Phillips 2018, Trends in Household Energy Expenditure, commissioned and prepared for by ACOSS and the Brotherhood of St Laurence, ANU Centre for Social Research Methods, https://www.acoss.org.au/wp-content/uploads/2018/10/Energy-Stressed-in-Australia.pdf, accessed 28 September 2020.

There are a broad range of benefits associated with increasing the energy efficiency standards for new residential buildings, in addition to reducing household energy bills, including:

- providing more comfortable living conditions – keeping the residents warmer in winter and cooler in summer, and reducing damp and mould
- positive heath impacts for their residents, including:
  - improved mental wellbeing due to reduced financial stress related to energy bills
  - improved physical health, for instance, decreased respiratory disease, cardiovascular disease, allergies, arthritis and rheumatism
  - reduced mortality during hot and cold spells
  - reduced family tensions and social isolation by improving the liveability of the home.[75]

3.4 Summing up

The discussion above suggests that, in principle, there is a case for an increase in the minimum energy efficiency requirements in the NCC for residential buildings on the basis of:

- existing market failures that inhibit socially optimal energy efficiency decisions including negative externalities associated with GHG emissions from energy consumption, informational barriers and split incentives
- recent policy commitments and directions
- available evidence suggesting that there are significant opportunities to further improve the energy efficiency of new residential buildings cost effectively
- the benefits that energy savings and lower energy bills can provide to households and society more broadly.

The case for increases in the energy efficiency provisions in the NCC is rigorously assessed in this RIS to determine whether proposed stringency increases are likely to be beneficial for Australian society overall.

[75] Energy Consumers Australia, *Power Shift, Healthy and comfortable homes for all Australians, Background paper*, September 2018

4 Objectives and options

4.1 Objectives of government action

Prior to 2010, the objective of energy efficiency requirements in the NCC was to reduce GHG emissions by efficiently using energy. The functional statement was:

> To reduce greenhouse gas emissions, a building, including its domestic services, is to be capable of using energy efficiently.

In 2010, the objective of the energy efficiency requirements in the NCC was simplified to reducing GHG emissions. The functional statement was expanded as follows:

> To reduce greenhouse gas emissions, to the degree necessary—
>
> (a) a building, including its domestic services, is to be capable of efficiently using energy; and
>
> (b) a building's domestic services for heating are to obtain their energy from—
>
> (i) a source that has a low greenhouse gas intensity; or
>
> (ii) a source that is renewable on-site; or
>
> (iii) another process as reclaimed energy.

In response to an action suggested in the Trajectory, part of the proposed changes to the NCC 2022 include broadening the objectives of the energy efficiency requirements in the NCC to:

— reduce energy consumption and energy peak demand
— reduce greenhouse gas emissions
— improve occupant health and amenity

As discussed in Section 3.3.1, the particular changes proposed to the energy efficiency requirements in the NCC for residential buildings have been driven by a number of broader policies, including:

— international commitments, in particular the Paris Agreement, and commitments by all Australian Governments to achieve net zero emissions by 2050 (or earlier)
— the NEPP, specifically Measure 31 that recommended the consideration of changes to the NCC to achieve better energy efficiency outcomes for Australia's buildings
— the Trajectory, which suggested a number of changes to increase the stringency of energy efficiency provisions in the NCC for residential buildings.

The broader objectives of these policies, and of the changes suggested to the energy efficiency requirements for residential buildings, can be summarised as to: [76]

- reduce energy costs for households and businesses
- maintain Australia's competitiveness and grow the economy
- reduce carbon emissions and improve sustainability.

Notably, these objectives implicitly indicate an objective of achieving *cost-effective* energy efficiency improvements (i.e. changes that deliver net benefits to the economy).

There are also a number of secondary objectives of the overall package of proposed changes. These include:

- increased clarity of the energy efficiency requirements (for instance, through quantification of Performance Requirements that are currently qualitative in nature)
- improving the effectiveness of the energy efficiency provisions (for instance, through the introduction of provisions to fully account for thermal bridging in the thermal calculations for residential buildings. Issues with thermal bridging in the current version of the NCC result in buildings that do not achieve the intended energy performance)
- reduce complexity, for instance by:
  - extending the elemental DTS provisions to Class 2 SOUs
  - offering a VURB pathway for Class 2 buildings.

4.2 Policy options

The objectives of the policies and commitments driving change of the residential energy efficiency provisions in the NCC (the international commitments, the net zero emissions commitments, the NEPP and the Trajectory and) are very broad and, as such, there are a wide range of policy measures that can contribute towards the achievement of these objectives. Many of these policy options are unrelated to energy efficiency of residential buildings (in fact, the NEPP outlines measures across a number of sectors in the economy) and outside the remit of the NCC and the ABCB. In light of this, the RIS focuses solely on policy options that relate to new residential buildings and are within the remit of the NCC and the ABCB.

Following the release of the CRIS, the ABCB investigated alternative regulatory options that had the potential to achieve increased energy efficiency with a greater BCR than the options explored in the CRIS. However, after further investigation of these options, the ABCB decided to keep the policy options unchanged.

The policy options formally considered in this Decision RIS and the alternative options that were assessed (but not adopted) in response to feedback in the CRIS are discussed in more detail in the sections below.

[76] COAG Energy Council 2015, *National Energy Productivity Plan 2015-2030*, P. 13.

4.2.1 Business as Usual (Status Quo)

The Business as Usual (BAU) or status quo is an option where there are no changes to the energy efficiency requirements for residential buildings in the NCC 2022.

The BAU sets up a baseline against which the impacts of the alternative options discussed below will be evaluated.

While the BAU benchmark assumes there are no changes to the energy efficiency requirements in the NCC, this does not imply that the baseline is static. There may exist, for example, a background level of voluntary adoption of additional energy efficiency measures in new buildings that occurs without changes in the NCC.

Essentially, the BAU portrays the ‘best’ representation of the foreseeable counterfactual and considers a range of factors, including:

— existing energy efficiency policies/measures for residential buildings
— the existing levels of compliance and over-compliance with the current NCC energy efficiency requirements
— changes in energy prices
— growth of the housing stock
— changes in the GHG intensity of energy
— other relevant ‘background’ variables.

More details about the factors accounted for in the BAU for the cost benefit analysis modelling are provided in Chapter 5.

4.2.2 Options A and B

The RIS formally analyses two policy options which are intended to apply to new residential buildings, Option A and Option B. These are described in more detail below. Option B is introduced first because it is the basis for calculating Option A.

Option B

This option sets a maximum annual energy use budget (based on societal cost[77]) for the elements of a building regulated by the NCC (space conditioning, heated water systems, lighting and pool and spa pumps). This is referred to as the Whole-of-house energy use budget. The budget is based on a ‘benchmark home’ built with the following characteristics:

— building shell performance level: equivalent to a 7 star NatHERS rated dwelling

[77] The societal costs of operating a building are the combined cost of the fuels used and the costs associated with the GHG emissions of each fuel type. Greenhouse gas emission costs are calculated by multiplying the energy use by the GHG intensity of each fuel type by a dollar value per tonne of GHG emissions (CO2-e). For further details about how the societal cost of energy is defined, please refer to the ABCB Scoping Study (https://consultation.abcb.gov.au/engagement/energy-efficiency-scoping-study-2019/).

- heating equipment: equivalent to a 4.5 star rated (GEMS 2012) heat pump heater (Annualised Energy Efficiency Ratio, AEER = 4.5) [78]
- cooling equipment: equivalent to a 4.5 star rated (GEMS 2012) heat pump cooler (Annualised Coefficient of Performance, ACOP = 4.5) [79]
- water heater: instantaneous gas
- 4 Watts per square metre of lighting.

Under this option, a societal cost of operating this benchmark building is calculated and a new building is deemed to be compliant if it has the same societal cost as the benchmark building. If a piece of equipment (e.g. water heating) is installed that performs worse than the benchmark, this will have to be offset either through installing other equipment that performs sufficiently better than the benchmark (e.g. cooling) or through the installation of on-site renewables (PVs).

Option A

This option is based on the same energy use budget as Option B, however, the budget is 70 per cent of the Option B benchmark (i.e. a compliant dwelling must achieve savings equivalent to 30 per cent of the societal cost of applying the equipment and building fabric performance level of the benchmark building specified in Option B). For example, if the societal cost associated with the benchmark building in Option B is $1,000 per annum, then under Option A societal cost of $700 must be achieved.

Compliance can be achieved either by improving the performance of the building shell, its equipment or by adding some PVs or a combination of these approaches.

No change is proposed to the existing lighting provisions in the NCC under any of the policy options.

Notably, the two proposed options will enable a ‘whole-of-house’ (WoH) approach to achieve compliance. This means that a dwelling’s annual energy use can be achieved within an energy budget, allowing a trade-off between the performance of individual building elements (such as the thermal shell, water heating and pool pumps), subject to a minimum level of thermal comfort being achieved (no lower than 7 star NatHERS rated performance, or equivalent)[80].

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[78] Under the latest 2019 GEMS determination, in terms of seasonal ratings, this would equate to 3 Stars i.e. a Heating Seasonal Performance Factor (HSPF) of 4.5.

[79] Under the latest 2019 GEMS determination, in terms of seasonal ratings, this would equate to 3 Stars i.e. a Total Cooling Seasonal Performance Factor (TCSPF) of 4.5.

[80] Trading between the thermal shell and equipment will not be possible when using the DTS elemental compliance pathway.

The existing pathways for demonstrating compliance with the NCC will remain, including combinations of:

— the Deemed-to-Satisfy (DTS) elemental provisions
— DTS NatHERS provisions
— verification using a reference building (VURB)
— Performance Solutions.

These pathways can be used to demonstrate compliance, but offer flexibility in achieving the objective for design.

A summary of the proposed changes to the NCC provisions is provided in Appendix A.

4.2.3 Alternative regulatory options assessed after consultation

As noted above, following the release of the CRIS, the ABCB investigated alternative regulatory options that had the potential to achieve increased energy efficiency with a greater BCR than the options explored in the CRIS. These options are discussed in more detail in the sections below.

A lower stringency benchmark for Whole-of-Home

The Consultation RIS analysed a benchmark based on a 4.5 star heat pump heating and cooling equipment. This alternative policy option entailed lowering the benchmark to 3 star (2012 GEMS) heating and cooling equipment, which would have the effect of lowering the stringency of the proposal through a greater whole-of-house energy use budget.

This option had the potential of increasing the BCR through lower capital costs to upgrade to less efficient equipment. However, initial analysis showed that the indicative improvements to the BCR for this option were small. Indeed, indicative analysis showed that:

— for Class 1 there was no improvement in BCRs
— for Class 2 there was a very minor improvement in BCRs.

Because this proposal did not improve outcomes relative to the existing options, and was lower stringency, it was not analysed in-depth or pursued any further.

Lower stringency thermal fabric provisions in northern climates

This option considered lowering the proposed minimum building fabric rating to NatHERS 6.5 stars in climate zones 1 to 3 (and retaining 7-stars for all other climate zones).

Tests on this option were carried out, which investigated the cost impact of this proposal on a selection of house designs used in the CRIS. This testing showed that, on average, reductions in cost were lower than the reductions in energy load, which would have resulted in an improvement in the BCRs of these climate zones, and an increase in the national average. However, due to other changes made for the central proposal that improved the national BCR (see Chapter 5 for more details), this option was not analysed in-depth or pursued any further.

Whole-of-Home only

This proposal would maintain the minimum efficiency of the building fabric at NatHERS 6 stars, however it would have increased the stringency of the WoH budget so that the energy savings were equivalent to Option A. This option would have allowed industry to achieve the same level of energy savings as the options proposed in the CRIS, but with flexibility to do it at the lowest cost by allowing the performance of the fabric to be lower if the performance of the equipment was greater. It also allowed 6 star fabric and/or inefficient equipment to be offset by installing more solar PV.

Analysis indicated that this option would have significantly increased the BCR of the proposal, through both lower costs and greater benefits from higher PV uptake.

This option was not adopted due to concerns that the majority of buildings would be built at 6 star, with more PV relative to Option A. The implications of this are:

- potential for greater energy use long term (relative to Option A) – the fabric is the longest lived part of a building and there is nothing compelling home owners to replace assets at the end of their life (like heating and cooling) with new assets that perform at the same or higher level, and there is a potential for solar PV to not be replaced
- there would be no improvement in thermal comfort in buildings
- poorer performing fabric leads to poor outcomes for the electricity grid, increasing peak demand (e.g. more electricity is used for cooling during peak periods), while better performing fabric smooths out the electricity demand profile
- a greater reliance on the installation of solar PV may increase electricity grid management challenges and risks, such as increased grid instability and increased price variability for consumers.

Removal of lighting provisions from energy efficiency provisions

During the development of the CRIS, the LCA took part in a preliminary consultation session with a select group of key stakeholders. They suggested that the technical stringency for lighting was prohibitive to a range of designs and that, due to its already high efficiency, lighting should be removed from the residential energy efficiency provisions of the NCC.

Separately, all stakeholders were invited to make comment of the draft NCC 2022 provisions during the Public Comment Draft (PCD) process. No stakeholders put forward a proposal to remove lighting from the residential energy efficiency provisions of the NCC.

Subsequently, the LCA made a submission to the CRIS suggesting that the lighting provisions should be removed from the residential energy efficiency provisions of the NCC arguing that:

- as a result of the high take up of LED lighting (to the point that they are industry standard practice) the NCC’s residential lighting energy efficiency provisions are no longer required
- the NCC’s provisions restrict the wider use of decorative/architectural lighting in new homes and that this impacts visual amenity and causes economic harm to the lighting manufacturing and lighting retail sales industry.

A lighting design (described by the LCA as typical) was submitted to the ABCB as an example of the type of installation where:

- general and task lighting consume the lighting wattage allowance prescribed in the NCC's residential energy efficiency provisions
- the use of decorative and architectural lighting will exceed the installed wattage allowances, resulting in the design not complying with the NCC.

The technical basis for the removal of lighting was assessed by the Department of Industry, Science, Energy, and Resources (DISER) lighting policy section. The ABCB was advised that:

- Lower cost and lower efficiency LED products exist in the market, and therefore the regulation of lighting efficiency has a role to play in maintaining higher efficiency levels in new housing.
- Lighting energy efficiency will soon be regulated under GEMS. However, this regulation will not extend to integrated LED luminaires used in lighting scene designs, further strengthening the case for lighting to be kept in the NCC.
- A review of the LCAs lighting design by an independent lighting designer found some irregularities in the calculation of lighting power density (W/m^2), more light fittings (relative to the size of the rooms) than normal, and some non-typical product selection. The lighting designer (who has many years of experience in lighting design and were part of the leadership group of one of the lighting peak bodies) concluded that if these matters were addressed, the design would likely become compliant with the NCC. The designer also advised that they (in their practice as a lighting designer) are comfortably able to achieve compliant residential lighting designs under the current lighting power density limits in the NCC.

The ABCB reviewed its policy position in recognition of the LCA's feedback and considered that the arguments and evidence provided were not sufficient to diverge from the policy direction set by the Trajectory.

The LCA submission to the CRIS also raised a number of second order impacts, including:

- reduced home amenity — it is argued that, when lighting designs are restricted, the desirability, usefulness, features and facilities of a home are compromised
- reduced home values — the LCA submission argues that, by limiting lighting design choices, the lighting requirements in the NCC diminish the value of a home
- reduced architectural and decorative lighting market — it is argued that, by limiting lighting designs, the NCC requirements reduce expenditure on lighting and negatively impact the decorative and architectural lighting market
- reduced employment in the construction sector — the LCA submission argues that a reduction in the number of installed lighting points will have a direct negative flow on effect to the electrical contracting market resulting in reduced employment.

In this respect, it is important to note that:

— Apart from the lighting design submitted to the ABCB, no evidence was provided by the LCA to support these impacts or to demonstrate that removing the cap would not significantly increase lighting energy consumption.
— Second order impacts are not able to be validated. The framework for impact analysis in a RIS is a CBA, which is a partial equilibrium framework that captures the first round (or direct) impacts of the proposed regulation on the construction industry and homeowners/residents, but not second and third round effects on associated industries. As such, a CBA framework does not consider the general equilibrium effects on the supply chain.
— Advice from DISER's lighting policy team suggests:
  – a need to encourage higher efficiencies in LED products
  – that the NCC does not prevent decorative/ architectural lighting being installed
  – maintaining the NCC lighting provisions is desirable.
— The LCA's claim that efficient LED lighting is common practice is contradicted to some extent by their claim the NCC prevents common lighting technology from being installed.
— The use of innovative products or designs is not inhibited by the NCC, as the ability exists for a Performance Solution to be used in cases where an innovative product or design is being considered.

4.2.4 Alternative non-regulatory approaches

The RIA Guidelines require that a RIS identifies a range of viable options, including, as appropriate, non-regulatory, self-regulatory and co-regulatory options.[81] As noted above, in the context of this RIS we will focus the discussion of alternative approaches to options that relate to improving the energy efficiency of residential buildings.

Non-regulatory approaches

Relevant non-regulatory approaches which focus on encouraging increased energy efficiency of residential buildings through information provision and incentives already exist in various forms at both the national and state level and many other options are being considered as part of the NEPP. For instance:

— most jurisdictions offer subsidies and rebates for energy efficient products and/or renewable energy [82]
— there are a number of building rating tools which can be used voluntarily to assess the energy performance of residential buildings (these are discussed in more detail in Box 4.1)

[81] Council of Australian Governments 2007, *Best Practice Regulation, A Guide for Ministerial Councils and National Standard Setting Bodies*, October, p. 10.

[82] A relatively recent list of these is provided in our 2018 report to Energy Consumers Australia, *supporting households to manage their energy bills: a strategic framework, https://energyconsumersaustralia.com.au/wp-content/uploads/Supporting-Households-to-Manage-Their-Energy-Bills-a-Strategic-Framework.pdf.*

- there are also voluntary industry schemes that provide information and training on environmental solutions for residential design and construction, for instance, the HIA GreenSmart Program and Master Builders' Green Living Program
- there are a number of initiatives that are being considered under Measure 32 of the NEPP (Increasing Compliance with the NCC) to improve compliance with current building energy efficiency regulation. These include the: [83]
  - provision of information, education and training to lift the capabilities of all relevant professionals and trades involved in the whole building development lifecycle
  - development of tailored compliance tools for building certifiers and government regulatory agencies to meet specific state and territory regulatory and administrative needs.

The persistence of an energy efficiency gap (the difference between potential and actual energy efficiency in buildings, see discussion in Section 3.3.2) highlights that voluntary approaches have had mixed results. As noted in the Trajectory '[m]ost buildings in Australia are only built to the minimum energy efficiency requirements in the National Construction Code (NCC). This misses cost effective opportunities to lower energy bills for households, as new energy efficient technology costs have been falling considerably in recent years, while energy prices have been rising. These requirements have also not been updated since 2010'. [84]

Box 4.1 Building rating tools in Australia which can be used voluntarily to assess energy performance of residential buildings

NatHERS

NatHERS provides an assessment of a home's thermal performance (building fabric/shell), with star ratings based on information about the home's design, construction materials and the climate where it is being built, and standardised assumptions about the occupant's behaviour profile.

NatHERS was originally developed to enable the house design community to identify optimal designs for new homes (and extensions) and to refine designs so as to deliver the best and most cost effective solutions for occupants. [85]

NatHERS is mostly used to demonstrate compliance with energy efficiency performance requirements in the NCC and so is mostly used for new houses and renovations. However, NatHERS is currently being extended to provide an assessment of the overall energy performance of homes and to establish NatHERS protocols and processes for existing home assessments (this includes further testing and refining of the national version of the Scorecard so that it may be accredited under NatHERS).

[83] COAG Energy Council 2018, *Report for Achieving Low Energy Homes,* December, P. 36.

[84] COAG Energy Council 2018, *Report for Achieving Low Energy Homes,* December, P. 1.

[85] Research Education Design (RED) and Strategy. Policy. Research. (SPR) 2020, *Extending NatHERS to In-Home Assessment of Existing Homes Discussion Report*, prepared for Department of Industry, Science, Energy and Resources, Exposure Draft Final Report.

BASIX

The Building Sustainability Index (BASIX) was introduced in 2004 by the NSW Government to regulate the energy and water efficiency of residential buildings. BASIX is used to satisfy the energy efficiency performance requirements in the NCC for NSW.

The assessment is conducted using an online BASIX tool, which estimates the water and energy consumption and the thermal comfort of a dwelling based on information about floor area, the size, location and type of windows, the type of insulation and the type of hot water system being installed. These estimates are then assessed and scored against specific energy and water reduction targets.

NABERS

The National Australian Built Environment Rating System (NABERS) is a national rating system that measures the environmental performance of buildings, tenancies and homes. It measures the energy consumption, water usage, waste management and indoor environment quality of a building or tenancy and its impact on carbon emissions.[86]

NABERS is predominantly used to rate commercial buildings, however, it is also used as a tool to assess the common areas and some shared services of Class 2 buildings. Unlike predictive tools, it can only be used for existing buildings and is designed to measure actual verified performance.

NABERS compares the performance of a building or tenancy to benchmarks that represent the performance of other similar buildings in the same location using real, measurable information about a building or tenancy, such as energy and water bills or waste consumption data.

In addition to the NABERS tools for commercial (and Class 2) buildings, NABERS maintains an online calculator for homes known as Energy Explorer. This ‘do-it-yourself‘ free tool does not offer certification or verification, but is rather an online calculator that is intended to enable homeowners to understand how energy is being used around the home and based on this, what the best savings options may be. It does not allow for in-home assessments by accredited assessors, but rather assumes that the tool is being used by the householder with access to in-home data. Based on the householder inputs, the calculator estimates annual energy consumption in kWh, annual energy costs (with user-defined energy prices) and GHG emissions.[87]

ACTHERS

In 1999, the Australian Capital Territory (ACT) became the first Australian jurisdiction to introduce a mandatory disclosure scheme for the energy efficiency performance of residential properties. The scheme used to give effect to this policy is known as the ACT House Energy Rating Scheme (ACTHERS).

The rating tool used to calculate ACTHERS ratings was derived from an early version of the NatHERS accredited tool, FirstRate. However, ACTHERS is not a NatHERS accredited tool. Originally it included a 0 – 6 star rating scale, rather than 0 – 10 as per NatHERS, but it has more recently adopted a 0 – 10 star scale consistent with NatHERS.[88]

Victorian Residential Efficiency Scorecard

The Victorian Residential Efficiency Scorecard (the Scorecard) is currently the only scheme conducting in-home assessments of existing houses in Australia. While the tool was originally developed for Victoria, it has been expanded to cover all capital city climates and tropical climates.

The Scorecard is based on an energy cost metric and gives householders information on:

— energy costs of a house as-built

— the performance of the home during heat waves with no cooling devices operational (a rating on the extent of overheating in hot weather)

— improvements to help save on energy costs.

The Scorecard certificate also breaks down how much energy is being used on heating, cooling, lighting, hot water, pools and spas and what proportion of energy is renewable if a home has solar panels. This information can be used by the householder: [89]

— as part of a decision-making process to buy or rent houses and apartments

— to make decisions on energy efficiency renovations, and communicate the value of an upgrade

— to consider behavioural actions to reduce their energy costs if renovations are not feasible.

Source: ACIL Allen based on the noted sources.

Quasi-regulation

The quasi-regulatory approach covers a wide range of rules or arrangements that are not part of explicit government regulation, but seek to influence the behaviour of businesses and individuals. Examples include industry codes of practice developed with government involvement, guidance notes, industry–government agreements and accreditation schemes.[90]

[86] NABERS 2020, *How it works – rating and certification*, https://www.nabers.gov.au/, accessed 22 July 2020.

[87] Research Education Design (RED) and Strategy. Policy. Research. (SPR) 2020, *Extending NatHERS to In-Home Assessment of Existing Homes Discussion Report*, prepared for Department of Industry, Science, Energy and Resources, Exposure Draft Final Report.

[88] Ibid.

[89] Isaacs, Tony 2018, *Technical Basis of the Victorian Residential Efficiency Scorecard – Version 1*, https://www.victorianenergysaver.vic.gov.au/__data/assets/pdf_file/0021/324183/Technical-basis-for-Scorecard.pdf, accessed 22 July 2020.

[90] Department of the Prime Minister and Cabinet 2020, *The Australian Government Guide to Regulatory Impact Analysis*, https://www.pmc.gov.au/sites/default/files/publications/australian-government-guide-to-regulatory-impact-analysis.pdf, accessed 17 September 2020, P. 30.

The Australian Government Best Practice Regulation Handbook (2007)[91] provides a checklist for the assessment of when quasi-regulation should be considered (Box 4.2). In light of these considerations and to the extent that:

- the residential construction sector is recognised as being highly fragmented and disjointed and quasi-regulation requires highly cohesive industries characterised by low rates of entry and exit
- there is already infrastructure to support the formal regulatory measures in the NCC; a code of conduct (or similar approach) would make aspects of the existing infrastructure redundant without necessarily achieving greater energy efficiency
- there is probably not one single industry association with the necessary capacity and resources to develop and/or enforce a national quasi-regulatory scheme

then, this approach to encourage voluntary uptake of higher energy efficiency standards in new residential buildings is unlikely to be effective for the construction industry.

Box 4.2 Checklist for the assessment of quasi-regulation

Quasi-regulation should be considered where:

- there is a public interest in some government involvement in addressing a community concern and the issue is unlikely to be addressed by self-regulation
- there is a need for an urgent, interim response to a problem in the short term, while a long-term regulatory solution is being developed
- government is not convinced of the need to develop or mandate a code for the whole industry
- there are cost advantages from flexible, tailor-made solutions and less formal mechanisms
- there are advantages in the government engaging in a collaborative approach with industry, with industry having substantial ownership of the scheme. For this to be successful, there needs to be:
  - a specific industry solution rather than regulation of general application
  - a cohesive industry with like-minded participants, motivated to achieve the goals
  - a viable industry association with the resources necessary to develop and/or enforce the scheme
  - effective sanctions or incentives to achieve the required level of compliance, with low scope for benefits being shared by non-participants
  - effective external pressure from industry itself (survival factors), or threat of consumer or government action.

Proposed quasi-regulation approaches should not restrict competition.

Source: Australian Government 2007, Best Practice Regulation Handbook, Canberra.

[91] Australian Government 2007, *Best Practice Regulation Handbook*, Canberra, http://regulationbodyofknowledge.org/wp-content/uploads/2013/03/AustralianGovernment_Best_Practice_Regulation.pdf, accessed 17 September 2020.

Summing up

In light of the discussion above, the RIS does not formally analyse alternative non-regulatory approaches to achieve the objectives of government action. This approach recognises that:

- there are a range of non-regulatory measures already in place to encourage increased energy efficiency of residential buildings at both the national and state level and many other options are being considered as part of the NEPP
- it has been acknowledged (through the NEPP, the Trajectory and other policies) that, to address the diversity of market barriers that exist in the residential building market, a suite of policies and tools are needed to drive increased energy efficiency in buildings (including regulation)
- the need for regulation in this space has been established in the past, with various regulations relating to energy efficiency already in place (not only the current energy efficiency provisions in the NCC but also the Commercial Building Disclosure (CBD) Program, and Minimum Energy Performance Standards and energy labelling for equipment).

5 Framework for analysis

This chapter outlines the approach to undertake the impact analysis for the RIS.

Consistent with best regulatory practice, the analysis of the impacts of the proposed increases to the energy efficiency provisions in the NCC was undertaken using a CBA framework.

CBA is an analytical tool used to assess the costs and benefits of regulatory proposals. Costs and benefits are examined from the perspective of the community as a whole to identify the proposal with the highest net benefit. This approach applies a with/without comparative metric that allows the analysis to specifically isolate the impacts of the incremental change in the NCC energy efficiency requirements from the ever-changing policy landscape.

Notably, the CBA relies on a number of technical reports commissioned by the ABCB, including (amongst others) the following:

— modelling of the impacts of the proposed thermal provisions (including thermal bridging) by TIC
— modelling of the impacts of the proposed WoH requirements by Energy Efficiency Strategies (EES)
— an analysis by AECOM of the impact of the NCC 2022 thermal provisions on blocks that may find it difficult to comply with the proposed changes
— an analysis by SGS Economics and Planning on the proportion of residential lots that may encounter difficulties implementing the proposed provisions
— an analysis by the Centre for New Energy Technologies (C4NET) on the propensity for new houses to take up solar PV.

5.1 General CBA framework

The following sections outline our approach to some general parameters used in the CBA.

5.1.1 Timeframe for analysis

The analytical timeframe used to model the costs and benefits of the proposed changes to the NCC is based on the following assumptions about the life of the regulation and of their associated impacts.

— The costs associated with the regulation are modelled for 10 years (see section on the effective life of the regulation).
— The benefits associated with the new NCC requirements will last as long as the life of the assets (e.g. the benefits associated with changes to water heating equipment last for 12 years - see Figure 5.1 and section below on the life of the regulation's impact).

The effective life of the regulation

Consistent with best practice and previous RISs, it is assumed that compliance and enforcement actions begin the year that the amendments take effect (2022) and are modelled to extend for a period of 10 years (that is, compliance costs were modelled for 10 years). After this period, it is assumed that in a normal cyclical policy review, a new cost benefit analysis results in either the regulations being superseded, revised or extended.

While the economic analysis in this RIS has been undertaken assuming that the proposed changes to the NCC start in 2022, in practice, it is anticipated that the regulations would start on the second half of the year and will likely have a transition period. As discussed later in the RIS, a transition period for the introduction of the proposed standards is likely to reduce the costs of the regulation.

The life of the regulation's impact

The additional benefits that will flow from compliance with the new NCC requirements will depend on the life of the assets installed to meet the regulation. Buildings are typically long-lived assets with a life of 40 years or more, whereas equipment is shorter-lived. In light of this, the following assumptions were used in the CRIS about the expected life of investments installed in new dwellings as a result of NCC 2022 (these assumptions are in line with the assumptions used in EES's WoH Report).

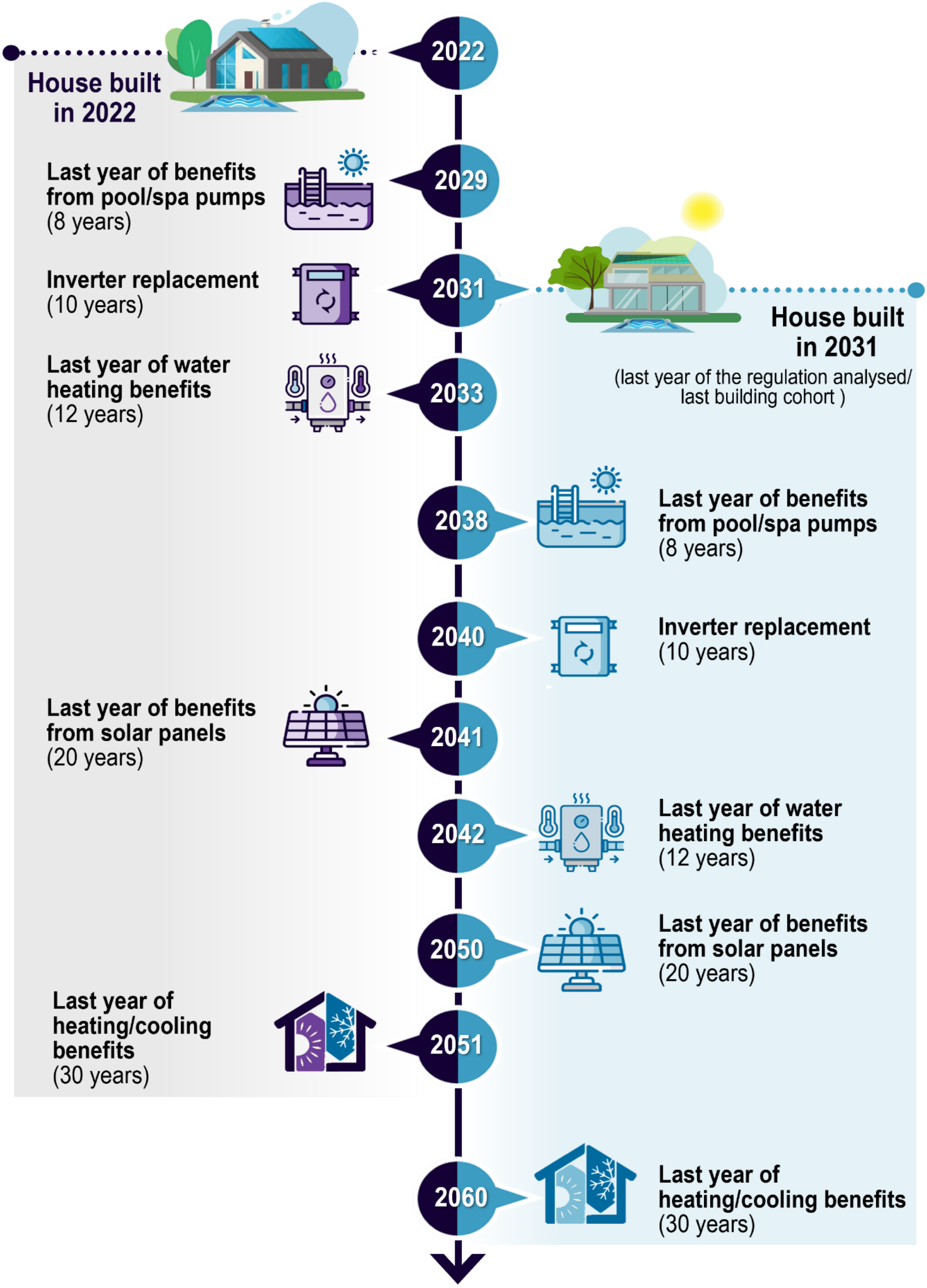
— Investments relating to heating and cooling that include a mixture of both shell and equipment measures are assumed to have an average life of 30 years, reflecting the fact that building shell improvements have a mixture of lifespans from 40 years for insulation, down to 15-20 years for door seals and that heating and cooling equipment has an average lifespan of 12 years. This, in essence, means that the benefits related to heating and cooling improvements are modelled for each building and each building cohort for 30 years.

— Investments relating to water heating equipment are assumed to have a lifespan of 12 years, and investments related to pool and spa pumps are assumed to have a lifespan of eight years.

— For investments related to PV, it was assumed that the solar panels have a lifetime of 20 years and that inverters (which are integral to the operation of the solar panels) last 10 years. It is also assumed that households will replace their inverter in year 11 so that the full 20 year benefits from the solar panels are realised.

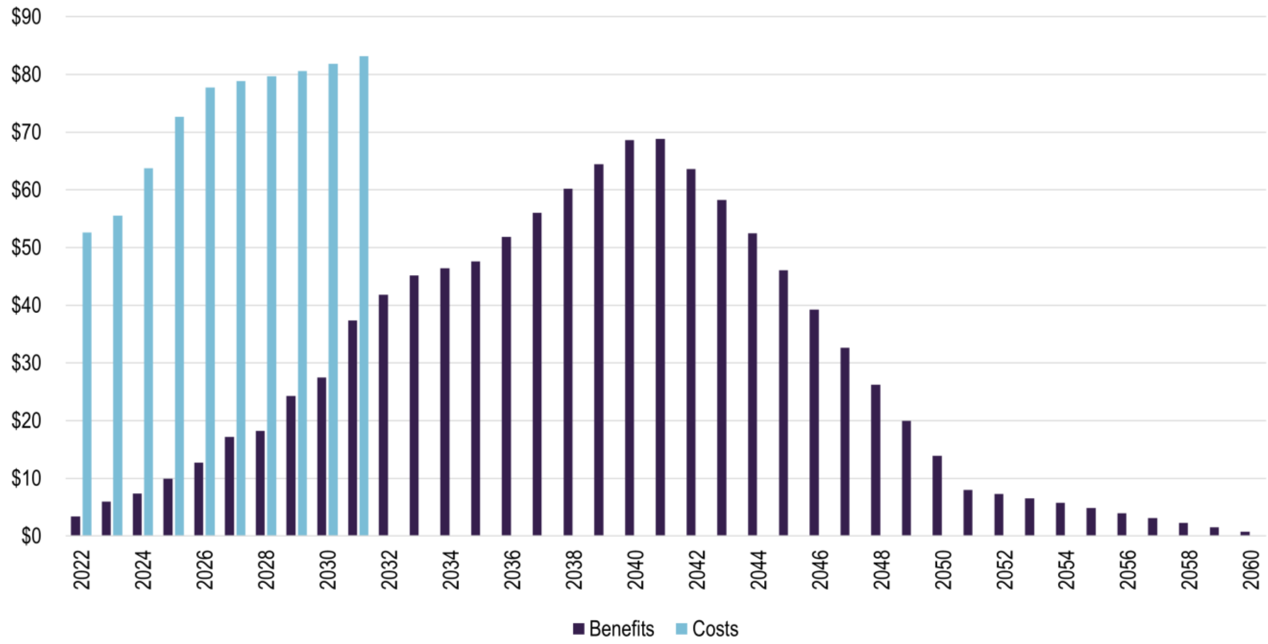
In essence, this approach means that the benefits of the energy efficiency measures installed as a result of the proposed changes will generally last as long as the life of the assets (e.g. water heating equipment for 12 years - see Figure 5.1). The only exception to this is PV inverters which are treated as a 'package' with solar panels. In comparison, costs are only incurred in the year the dwelling is built (with the exception of inverters which are replaced after 10 years). This treatment of costs and benefits results in a similar profile to that shown in Figure 5.2, where costs are incurred for 10 years, and benefits last until 2060, when the benefits of the last building cohort (built in 2031) end.

Figure 5.1 Lifetime of benefits from the proposed regulation



Source: ACIL Allen.

Figure 5.2 Illustrative profile of costs and benefits for building cohorts built during the effective life of the regulation (2022-2031)



Source: ACIL Allen.

Some submissions received during consultation questioned the ten-year period for assessing the regulation's impact and the lifespan of impacts. These arguments are of two kinds:

— the ten-year lifespan is inadequate because the lifespan of residential buildings is significantly longer, and

— the impact analysis should include multiple replacements of "like-for-like" equipment (including PV) over the life of the building. They point out that equipment continues to improve and therefore households should continue to invest in reinstalling this type of equipment. This point was made by the Victorian Government, AGWA and another submission.

The first argument conflates the timeframe of the analysis with the length of time that the impacted cohort is drawn from. While the ten-year period defines the cohort of new-builds analysed, the timeframe of the analysis is instead defined by the reasonable lifespan of the equipment upgraded. As mentioned above, a ten-year cohort is standard for impact analysis done within the RIA Framework and consistent with similar RIS which have been prepared in the past. After this period, it is assumed that in a normal cyclical policy review, a new cost benefit analysis results in either the regulations being superseded, revised or extended.

The second argument assumes that the treatment cohort and its baseline (no-change) pair are not making the identical decision to install energy efficient equipment in the future. The cost benefit analysis needs to account for impacts which are caused by the implementation of a regulation in comparison to the baseline.

Future equipment decisions for affected households, which are outside the control of the NCC, will be made by the residents at some point in the future. It is a reasonable assumption that under the baseline scenario and in the policy scenarios, those households will have the same access to information, market options, and capital. Not including reinvestments in a like-for-like equipment does not preclude households from making that decision. Instead, it implicitly assumes that households will make the same decision in a policy and baseline scenario.

There was an argument that the decision to reinstall solar PV is greater in a policy scenario where it has been installed at the time of the new build compared with the baseline — that the decision follows hysteresis. There are two elements of this:

- the cost of solar is decreasing over time while performance is improving, and
- when solar panels reach the end of their life, the impact on household bills is large and noticeable under the policy scenario which induces additional loss-avoidance.

The first point, while likely true, is likely to be the same in the baseline and any policy scenarios. It is also likely to be true, to a certain degree, for all other types of equipment as well. Households will face the same decision under both the baseline and policy scenarios.

The second point assumes that loss-avoidance will work as a behavioural driver for those households that have installed solar PV under the policy scenarios. While this may be a driver, the conditions for solar are likely to be materially different in twenty to thirty years (at the point of replacement) as per the first point. It is impossible to know the relative importance of behavioural drivers relative to everything else that will change in the intermediate period. Therefore, it is difficult or impossible to say with any certainty whether loss-avoidance will be a material driver of outcomes from the policy decision in twenty to thirty years.

The approach taken to asset replacement in the CRIS is consistent with the approach used in other energy efficiency RISs and is considered appropriate for the assessment of the NCC requirements as once a piece of equipment needs replacement in the future there is no regulatory mechanism via the NCC to ensure that it is replaced with another that is at least as energy efficient as the first one. Hence, the benefits stemming from the NCC requirements are only modelled for as long as the assets installed to meet the regulation are expected to last.

5.1.2 Discount rate

There is extensive debate around the basis and selection of the appropriate rate to discount the stream of costs and benefits of policy changes related to energy efficiency, as the rate used in RIS assessments has a very significant impact on the value placed on the benefits accumulated in the future over a long period of time.

The OBPR requires the calculation of net present values at an annual central real discount rate of 7 per cent, with sensitivity analysis conducted using a lower bound discount rate of 3 per cent and an upper bound discount rate of 10 per cent. Recent ABCB RISs[92] have used these recommended discount rates, and HoustonKemp in their report *Residential Buildings Regulatory Impact Statement Methodology*[93] also suggest using these values (although they also suggest reporting evaluation results using a 5 per cent discount rate).

In contrast, a number of countries have used lower discount rates for evaluating policies or regulatory changes associated with energy efficiency or environmental outcomes, for instance:

— The New Zealand Treasury recommends a standard discount rate for all regulatory appraisals of 8 per cent. However, a number of RISs have used lower discount rates when there are environmental or energy efficiency concerns. For example, a RIS for updating energy efficiency regulations for air conditioners used a 5 per cent rate, citing "the value of long term environmental and social benefits associated with energy efficiency".[94]

— HoustonKemp notes that, in the United States (US), "the Department of Energy recommends using a 3.0 per cent real discount rate (2.5 per cent nominal) for projects relating to energy conservation and renewable energy sources".[95]

— The Intergovernmental Panel on Climate Change (IPCC) recommends using the following discount rates for projects with long term impacts: a 3.5 per cent discount rate for 1-30 years, a 3 per cent rate for 31-75 years, a 2.5 per cent rate for 76-125 years, a 2 per cent rate for 125-200 years, a 1.5 per cent rate for 100-300 years, and a 1 per cent rate for a longer period.[96]

Following guidance from OBPR, the discount rate used in the CRIS was 7 per cent (real) with sensitivity analysis conducted using a discount rate of 3 per cent and 10 per cent.

Submissions received during consultation were varied in their views on the appropriateness of the discount rate. Stakeholders provided arguments to variously raise or lower the central discount rate. The arguments for a change in the discount rate can be summarised into three kinds:

— Household energy efficiency should be measured at the opportunity cost on the investment decision for households, which suggests a higher discount rate. HIA argues that, in general, the discount rates for households are higher than 7 per cent, nominating several papers[97] which

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[92] The Centre for International Economics (CIE) 2018, *Decision Regulation Impact Statement, Energy Efficiency of Commercial Buildings,* prepared for the Australian Building Codes Board, November; Strategy. Policy. Research (SPR) 2018, *Inclusion of heating and cooling energy load limits in NatHERS assessments, Regulation Impact Statement for decision*, prepared for the Australian Building Codes Board.

[93] HoustonKemp 2017, *Residential Buildings Regulatory Impact Statement Methodology*, report for the Department of the Environment and Energy, April.

[94] Ibid, p. 7.

[95] Ibid. p.7.

[96] IPCC, 2007, cited in ASBEC 2016, *Building Energy Performance Standards Project, Issues Paper*, April.

[97] Hausman, J. A. 1979, *Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables*, The Bell Journal of Economics, 33-54; Newell, R. G., & Siikamaki, J. V. 2015, *Individual time preferences and energy efficiency*, American Economic Review, 196-200.

argue that households use a discount rate closer to 20 per cent for energy efficiency decisions. This argument suggests a higher central rate.

- Several submissions and survey responses pointed out that the 7 per cent discount rate is well above current public and private borrowing rates or current inflation rates. These include submissions from Renew and AGWA. These submissions likewise refer to the opportunity cost of the investment in energy efficiency, and point out that 7 per cent is well above the current market time-cost of money for both savings and borrowing. This argument suggests a lower interest rate closer to market rates between 3 and 5 per cent.
- Several submissions focused on the intergenerational equity implications of a 7 per cent discount rate. These responses note that a high discount rate inadequately captures long-term impacts on future generations, and that individual time-preferences underpinning a 7 per cent discount rate are not capable of reflecting the preferences of future generations. These responses argue for a very-low or zero discount rate for the cost-benefit analysis to account for the climate-change nature of the policy. This argument suggests a much lower discount rate between zero and 3 per cent.

To ensure compliance with OBPR's requirements and consistency of comparison with other economic analysis of energy efficiency measures in the NCC, the Decision RIS continues to use a central discount rate of 7 per cent, with sensitivity analysis provided at 3 per cent and 10 per cent. However, it is important to note that recently updated guidance by OBPR for incorporating environmental impacts and uncertainty into regulatory impact analysis suggests that for analyses involving very long timeframes it is appropriate to use a time declining discount rate. In particular, it is recommended that for analyses involving a period of analysis of between 31 and 75 years, the central discount rate declines from 7 per cent to 5.4 per cent after 30 years.[98] This change in discount rate over time has not been incorporated in the central case, but has been tested via sensitivity analysis.

We also believe that the provision of sensitivity analysis of the results using a discount rate of 3 per cent is sufficient to understand the effects of the policy when lower discount rates are used (like the ones recommended by the IPCC and used in the US).

5.1.3 Cost benefit summary measures

The CBA model includes two summary measures that distil the results of the analysis, as described in Table 5.1.

[98] OBPR 2020, *Environmental Valuation Guidance Note,* Department of the Prime Minister and Cabinet.

Table 5.1 Summary of measures included in the CBA

Summary measure	Description	Success measurement	Comparative ability
Net present value (NPV)	Sum of discounted annual net benefits (benefits minus costs)	Policy is beneficial to society if NPV is greater than zero	Provides the ability to compare policy options according to the total economic return of each, where the option with the largest NPV should be favoured
Benefit-cost ratio (BCR)	Ratio of the present value of total costs to the present value of total benefits	Policy is beneficial to society if BCR is greater than one	Provides the ability to compare policy options according to the degree to which benefits outweigh costs for each, where the option with the largest BCR should be favoured

Source: ACIL Allen.

5.1.4 Compliance

The analysis assumes full compliance with the new energy efficiency requirements. While in reality not all new constructions are likely to comply with the requirements fully, this is a standard assumption in regulatory analysis.

Currently, the following pathways exist to demonstrate compliance with the NCC energy efficiency requirements:

- **Class 1 dwellings** can comply using one of the following pathways (or a combination of them):
  - the DTS elemental provisions
  - DTS NatHERS pathway
  - verification using a reference building (VURB)
  - Performance Solutions.

  The ABCB estimates that around 80 per cent of new Class 1 buildings in Australia use NatHERS accredited software as their means of demonstrating compliance with the NCC. The remaining 20 per cent of Class 1 buildings use a mixture of other pathways for compliance

  Available compliance pathways for Class 1 buildings remain the same in NCC 2022.

- The only DTS compliance pathway currently available for **Class 2 SOUs** requires a unit-by-unit approach using NatHERS. SOUs are required to meet a 6 star NatHERS rating on average across a Class 2 building, with no SOU allowed to achieve less than 5 stars (a certificate for every SOU is required). Compliance with climate zone specific minimum heating and cooling load limits must also be met both on average across the building and at the SOU level. Provisions for the common areas of Class 2 buildings are also captured in the Volume 1 Section J.[99]

[99] Team Catalyst 2020, *VURB for Class 2 – Method Document*, November.

As part of the proposed changes under NCC 2022, two new compliance pathways are being added for Class 2 dwellings, a DTS elemental pathway and a VURB pathway.

While in reality the proportion of buildings using different pathways to demonstrate compliance with the NCC will vary by class and by state and territory[100], for the CBA it has been assumed that the costs and benefits associated with the NCC 2022 are the same between compliance pathways. The rationale behind this assumption is as follows:

— The DTS elemental provisions created by TIC for NCC 2022 were developed so that the *additional* costs and benefits of following this pathway are almost identical to following the NatHERS pathway. This outcome has been independently verified by Arup.
— Due to the above, the technical inputs by EES and TIC (the energy savings and compliance costs for individual dwelling types – which are the foundation of the economy-wide CBA) were only provided to us for one compliance pathway (NatHERS) for both Class 1 and Class 2 buildings.
— The ABCB expects that the *additional* compliance costs and benefits between pathways would be similar (although the use of Performance Solutions provides the opportunity to reduce cots or improve the benefits). Furthermore, while the ABCB does not expect the new requirements will 'force' a change in which compliance pathway builders choose to use, it was noted that:
  – the new DTS elemental provisions for Class 1 buildings are simpler to use (due to changes in methodology and the assistance of calculators), which may result in more builders using this pathway and in some compliance cost savings
  – the new voluntary VURB for Class 2 buildings allows a building to be rated as a whole (similar to the verification method used for commercial buildings)
  – the new DTS compliance pathway for Class 2 buildings may result in some compliance cost savings if taken up
  – buildings would need to meet the mandatory Performance Requirement regardless of the compliance pathway taken, and hence would need to achieve at least the minimum energy savings.

5.1.5 Cost pass-through

Consistent with previous analyses, for this RIS, we assumed that the additional compliance costs associated with the construction of a new dwelling are passed through in full to the consumer.

5.1.6 Rebates

There are currently a number of rebates and other subsidies for energy efficiency and renewable energy measures across states and territories.

While from a household's perspective it is reasonable to factor any rebates into the cost of installing energy efficiency measures, as a general rule, subsidies are excluded from the economy-wide CBA as, from the societal perspective, they do not represent a resource cost, but just a transfer.

[100] Including Class 4 parts of buildings.

In light of this, any subsidies currently in place for energy efficiency and renewable energy measures are excluded from the economy-wide CBA. However, any rebates included in EES's Whole-of-home modelling are included in the distributional analysis (i.e. the analysis of the proposed changes from the perspective of households living in the dwellings that would be subject to the NCC 2022).

EES included the following rebates in their modelling for the CRIS: [101]

— Solar PV — EES included an average level of Small-Scale Technology Certificate (STC) rebates over the 10 year period of the regulation (starting in 2022). An average of four years of credits was applied being the average number of credits applicable over the period (current rebates effectively end in 2030).
— Water Heaters (solar and heat pump types only). For smaller units (those in Class 2 dwellings) an average of 20 STCs was assumed and for larger units (those in Class 1) an average of 25 STCs.

During consultation, a submission argued that the value of credits for STCs at the household level should be on an annual rather than average basis. In response to this feedback, EES has changed the assumption in its model to reflect annual rather average credits. This change flows through the household analysis in the Decision RIS.

5.1.7 Interactions with state and territory legislation

While the NCC is a national code, states and territories can choose which provisions of the code are 'called up' within their legislative frameworks, and can also vary these provisions. As such, the energy efficiency provisions in the NCC are applied with variations in some states and territories. Throughout Australia, there are individual jurisdictions which apply different levels of energy efficiency for housing, for instance:

— for residential energy efficiency the Northern Territory (NT) building regulations call up the 2009 version of the NCC. This results in a minimum of:
  – 5 stars for Class 1
  – 3 stars for individual Class 2 sole occupancy units and an average of 3.5 stars across all units
— the Queensland development code provides dwellings built with solar PV an optional 1-star credit that in effect allows a dwelling to achieve a NatHERS star rating less than the NCC minimum requirement
— in NSW, Class 1, 2 and Class 4 parts of buildings are subject to the NSW BASIX (Building Sustainability Index) provisions, rather than the energy efficiency provisions of the NCC.

Consistent with previous RIS analyses, this RIS does not address the interaction between the proposed amendments to the NCC and the existing and planned state and territory regulations. The analysis assumes that each of the states and territories will apply the NCC in its jurisdiction and compares the current NCC requirements to the proposed new requirements.

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[101] More details about the treatment of these rebates in EES's modelling can be found in found in EES's report '*NCC 2022 Update - Whole of Home Component'.*

The analysis does take into account provisions within the NCC that only apply in certain climate zones. This represents a change from the approach taken in the Consultation RIS. As discussed in Table ES.1, the analysis takes into account the OLA concessions that apply only in climate zones 1 or 2 (when using the NatHERS compliance option).

Therefore, the baseline for this RIS is that all new buildings across Australia rate 6 stars or above, and this is compared to a situation where all new buildings achieve 7 stars and the WoH requirements. Where an OLA concession applies, the baseline is 5 stars for the building fabric, compared to 6 stars under the proposed provisions.

Given this, the results of the analysis in this RIS should be interpreted as to represent the costs and benefits associated with increasing the building shell performance level of new buildings from the baseline set by NCC 2019, compared to NCC 2022. No state or territory variation is included in the baseline.

This approach allows for a like with like comparison between states and with previous RISs and avoids having to make assumptions about the likely policy responses of different states and territories.

Notably, all the technical modelling undertaken by TIC and EES (which underpins the analysis in this RIS) was also done on the same basis. Reflecting jurisdictional variations would have required extending these analyses.

5.2 Baseline for analysis

As noted in Section 5.1, the effects of the proposed policy options are estimated by comparing their impacts with the baseline or BAU scenario. The baseline is a projection of the future state of the world in the absence of any policy or regulatory change.

The objective of the CBA is to assess the change brought about by the new proposed energy efficiency requirements in the NCC. As such, the baseline should make specific reference to those factors which will be affected by the regulation and which will affect the estimates of its impact. To this end, to establish the baseline for the analysis in the RIS we considered:

— the energy efficiency of new buildings (i.e. the distribution of thermal ratings achieved in practice and the proportion of new houses already installing solar PVs)
— the growth in the building stock
— changes in energy consumption and prices (this is discussed in more detail in Section 5.5).

The definition of these baseline elements represents the best estimate of how the world might look given the information available today.

Additional information about each of the first two elements is provided in the sections below.

5.2.1 Baseline energy efficiency

Thermal efficiency

The Commonwealth Scientific and Industrial Research Organisation's (CSIRO's) Australian Housing Dataset contains information about the current distribution of star ratings in each NatHERS and NCC climate zone (NCC CZ)). This analysis shows that in all states and climate zones, there is a level of compliance above that required by the NCC (over compliance), with many dwellings being built at higher ratings than the minimum 6 stars required (see Table 5.2 below). The proportion of dwellings being built at ratings lower than 6 stars reflect a mix of:

— the jurisdictional differences in the application of the NCC outlined in Section 5.1.7

— possible non-compliance.

Table 5.2 Distribution of Class 1 and Class 2 ratings by state from CSIRO Australian Housing Data Dashboards

	<=4 stars	4.5 stars	5 stars	5.5 stars	6 stars	6.5 stars	7 stars	7.5 stars	8 stars	8.5 stars	9 stars	9.5 stars	10 stars	Total 7 stars and above
Class 1														
ACT	0.1%	0.0%	1.0%	1.3%	41.2%	21.3%	17.5%	9.8%	4.6%	2.6%	0.4%	0.2%	0.0%	35.1%
NSW	4.8%	7.7%	24.7%	23.1%	18.3%	12.1%	6.2%	2.1%	0.7%	0.2%	0.0%	0.0%	0.0%	9.3%
NT	0.0%	0.0%	13.5%	13.7%	27.5%	20.4%	15.3%	8.5%	0.8%	0.3%	0.0%	0.0%	0.0%	24.9%
QLD	0.3%	1.4%	13.0%	8.7%	34.1%	16.6%	12.4%	8.1%	3.5%	1.3%	0.5%	0.1%	0.0%	25.9%
SA	0.2%	0.4%	2.7%	0.9%	75.3%	14.2%	4.8%	1.1%	0.4%	0.1%	0.0%	0.0%	0.0%	6.3%
TAS	0.3%	0.1%	0.2%	0.1%	55.5%	27.7%	13.3%	2.4%	0.4%	0.1%	0.1%	0.0%	0.0%	16.2%
VIC	0.2%	0.1%	0.3%	0.3%	84.5%	11.0%	2.8%	0.5%	0.2%	0.0%	0.0%	0.0%	0.0%	3.6%
WA	4.9%	1.9%	2.5%	1.5%	65.4%	11.1%	7.2%	3.3%	1.5%	0.4%	0.2%	0.1%	0.0%	12.8%
Class 2														
ACT	0.0%	0.3%	4.1%	7.0%	10.3%	9.3%	16.5%	21.3%	14.4%	12.5%	4.4%	0.0%	0.0%	69.0%
NSW	8.5%	8.6%	13.2%	15.9%	13.8%	13.3%	11.7%	8.0%	4.6%	2.0%	0.4%	0.1%	0.0%	26.7%
NT	0.0%	0.8%	3.8%	5.3%	13.6%	8.3%	22.0%	22.0%	23.5%	0.0%	0.0%	0.8%	0.0%	68.2%
QLD	10.9%	11.5%	13.9%	12.3%	12.6%	9.3%	9.0%	8.1%	6.1%	3.7%	1.9%	0.4%	0.3%	29.5%
SA	0.0%	0.0%	11.4%	15.0%	22.4%	16.6%	17.1%	9.0%	7.4%	1.1%	0.1%	0.0%	0.0%	34.6%
TAS	0.7%	0.0%	2.5%	3.4%	14.6%	22.1%	24.4%	16.4%	9.8%	5.2%	0.9%	0.0%	0.0%	56.7%
VIC	0.2%	0.2%	7.0%	11.4%	18.3%	20.6%	18.5%	14.1%	7.4%	2.1%	0.3%	0.0%	0.0%	42.5%
WA	0.2%	0.1%	9.3%	8.3%	18.1%	13.7%	13.1%	15.2%	13.0%	5.8%	2.8%	0.3%	0.3%	50.5%

Note: Based on data from 2016 to March 2021. Totals may not add up due to rounding.
Source: CSIRO Australian Housing Dataset.

The current level of energy efficiency of new residential buildings, and how this is expected to change in the future, is taken into account when assessing the costs and benefits of increasing the minimum thermal standards in NCC 2022. Dwellings already built at 7 stars or above have no additional costs or benefits as a result of the new 7 stars building fabric requirements. However, the costs and benefits associated with the WoH component are taken into account for these buildings, where these buildings were not already meeting these requirements.

For the purpose of the CBA it was assumed that current levels of over compliance will continue (for instance, it was assumed that approximately 4 per cent of Class 1 dwellings and 42 per cent of Class 2 SOUs in Victoria will continue to be built at 7 stars or above under the baseline). Industry stakeholders consulted for the CRIS agreed with this approach and no objections to this approach were received during consultation. Furthermore, while in practice the WoH approach will allow trade-offs between the performance of individual building elements, subject to a minimum level of thermal comfort being achieved (no lower than 7 star NatHERS rated performance, or equivalent), the CBA assumes that dwelling that are being built above 7 stars would have similar impacts to those built at 7 stars (i.e. it is assumed that dwellings being built above 7 stars have the same costs and benefits as a 7 star dwelling).

This assumption is necessary as the WoH modelling undertaken by EES does not account for thermal performance variations. Given the complexity of simulating multiple potential trade-offs associated with the WoH provisions, EES's modelling simulates a fixed level of thermal comfort (at the minimum 7 star NatHERS) and determines the equipment (including solar PVs) that needs to be installed to meet the required energy budget based on this rating. As noted earlier, in reality, buildings can meet the required energy budget through a higher performance building shell, higher efficiency equipment, on-site renewables (solar PVs) or a combination of these. Different choices regarding how to meet the required energy budget would impact both the costs and benefits for buildings.

As noted in Sections 5.1.4 and 5.1.7, the RIS assumes full compliance and does not account for current variations in the application of the NCC in different states and territories (noting that the OLA provisions are accounted for in the DRIS analysis). In light of this, any 'perceived' undercompliance[102] with the current 6 star requirement in the NCC is not taken into consideration in the analysis.

Current use of solar PVs

There are a number of new dwellings currently being built with solar PV. With the introduction of WoH requirements in NCC 2022 these dwellings may already have sufficient solar PV capacity installed to meet the NCC 2022 Performance Requirement. Given this, the proportion of new residential buildings built with solar PV, and how this is expected to change in the future, was taken into account when assessing the costs and benefits of the new energy efficiency requirements in the NCC 2022.

[102] As noted above, levels of compliance below 6 stars are in some instances a result of state/territory variations in the application of the NCC, and so do not reflect real undercompliance.

Two key inputs are required to account for these dwellings in the economic modelling:

— an estimate of the proportion of new dwellings that are fitted with solar PV at time of construction and projections about how this is expected to change over the period of analysis
— an estimate of the average capacity of the solar PVs installed in new dwellings and assumptions about how this is expected to change over the period of analysis.

Proportion of new dwellings fitted with solar PV at time of construction

The CRIS estimated the proportion of new dwellings fitted with solar PV at time of construction for all jurisdictions except NSW using ACIL Allen's in-house Small Scale Renewable Energy Model (SSREM) and analysis undertaken by C4NET for the ABCB estimating solar PV penetration in new dwellings under the BAU in Victoria.[103] For NSW, the NSW Government provided detailed actual data from BASIX on the proportion of new buildings with solar PV by climate zone in NSW.

Feedback by PCA, ASBEC, GBCA and EEC provided during consultation argues that the RIS should assume that no incremental PV costs are incurred in at least 27 per cent of new houses (this submission notes that this is the percentage of all households that have installed PV systems). In response to this feedback it is noted that:

— The methodology in the CRIS (and this Decision RIS) already recognises that there are a number of new dwellings built with solar PV under the baseline and that these dwellings may already have sufficient solar PV capacity installed to meet the proposed new requirements (and hence would not experience incremental costs with the introduction of the WoH requirements).
— The PV penetration rate suggested by the joint submission refers to the proportion of all residential dwellings and small businesses with solar PV installations. As noted in the CRIS, while statistics related to the overall number of residential buildings with solar PV installed and the average capacity of these systems are readily available, these statistics do not include specific information about solar PV systems in new dwellings.

After the CRIS was published, the ABCB commissioned C4NET to extend their analysis to Queensland and NSW/ACT. The findings from this analysis are summarised in Table 5.3.

Table 5.3 C4NET analysis of the propensity for new houses to take up solar, 2019

	Proportion of new houses built with PV	Average system size
NSW	31%	5.77 kW
Victoria	14%	5.43 kW
Queensland	16%	6.70 kW

Source: C4NET.

Based on the updated C4NET analysis, the percentage of new buildings with PV installed under the baseline in 2019 was updated in the Decision RIS analysis as per Table 5.4.

[103] More details of this approach are provided in Chapter 4 of the CRIS.

- For NSW, the Decision RIS continues to use the BASIX data on the proportion of new houses built with PV.
- For Victoria and Queensland, we used the updated C4NET data on PV penetration.
- For all other states, it was assumed an average penetration of 16 per cent (based on an average of BASIX data and C4NET data for Victoria and Queensland).

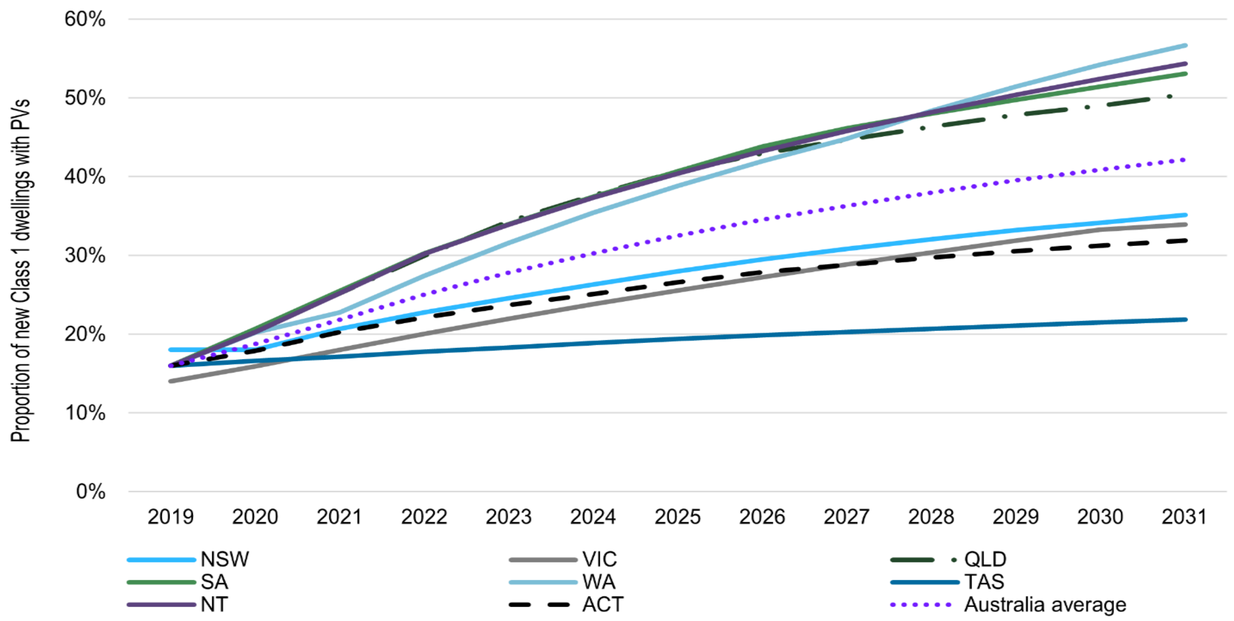
It is also assumed that the proportion of dwellings with solar PV installation is the same across different climate zones in each jurisdiction (except for NSW where the solar PV penetration by climate zone was provided). We then projected the change in these installations over the period 2019-2031 using the SSREM (see Figure 5.3).

Table 5.4 Assumptions used in the Decision RIS regarding solar PV penetration for 2019

	Proportion of new houses built with PV	Average system size
NSW	18%	6 kW
ACT	16%	6 kW
Victoria	14%	6 kW
Queensland	16%	7 kW
South Australia	16%	6 kW
Western Australia	16%	6 kW
Northern Territory	16%	6 kW
Tasmania	16%	6 kW

Source: ACIL Allen based on C4NET and BASIX data.

Figure 5.3 Projected proportion of new Class 1 residential buildings with solar PV, 2019 to 2031



Source: ACIL Allen.

Average capacity of the solar PVs installed in new dwellings

Feedback by PCA, ASBEC, GBCA and EEC provided during consultation argues that the average size of PV systems in new houses should be assumed to be 8.86 kW, not 5kw as per the CRIS (this suggestion is based on the Australian Energy Council's quarterly Solar Report which reports that the average solar system size for residential and small businesses has increased from 2.65 kW in January 2012 to a peak of 8.86 kW in December 2020).

Renew and the New England Greens also share the view that the average size of PV in new houses is larger, although they do not offer a specific size to be used.

As noted above, the information used by PCA, ASBEC, GBCA and EEC to suggest an increase in system capacity relates to statistics that include both existing and new dwellings and small businesses with solar PV installations and the inclusion of small business in the existing statistics tend to distort the average system size upwards.

For the Decision RIS, we updated the assumed size of solar PV systems in new houses based on the updated C4NET analysis outlined in Table 5.4.

— For NSW, the Decision RIS continues to use the BASIX data on the average system size.

— For Victoria and Queensland, we used the updated C4NET data average system size.

— For all other states, it was assumed an average system size of 6kW.

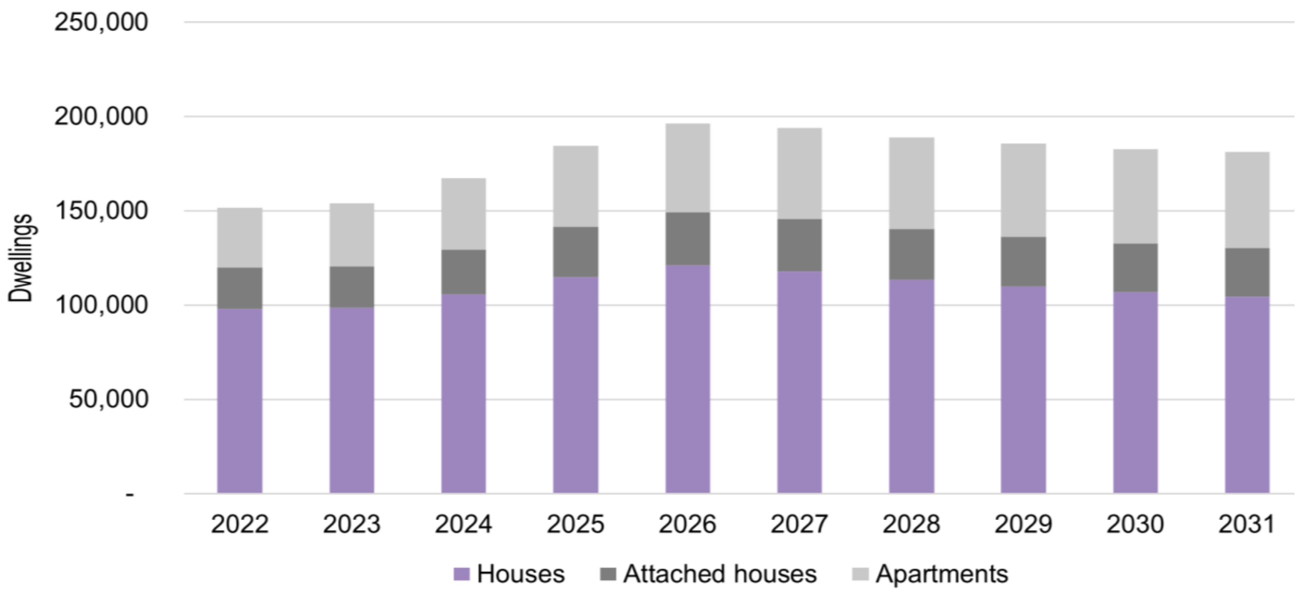
These assumptions are held constant for the analysis period (that is, it is assumed that under the BAU, all new buildings installing solar PVs at the time of construction will install systems as per Table 5.4).

5.2.2 New residential building stock

We do not expect that the proposed changes to the NCC will impact on the numbers of new residential buildings constructed. Nevertheless, growth of the residential stock is a key driver for both costs and benefits of the proposed amendments, and distributional issues in the analysis.

For the analysis in the RIS, we produced baseline projections of the housing stock in Australia over the period 2022 to 2031. These projections are primarily based on historical ABS approvals data and ABS forecasts of the Australian housing stock. We also used Housing Industry Association (HIA) information on projected dwelling commencements to inform adjustments to our projections in the short term due to COVID-19. Our projections see the number of new dwellings increase from just above 150,000 dwellings in 2022 to around 181,000 dwellings by 2031 (see Figure 5.4 and Figure 5.5).

Figure 5.4 Projected number of new residential dwellings by dwelling type, Australia, 2022 to 2031



Source: ACIL Allen.

Figure 5.5 Projected number of new residential dwellings by state, 2022 to 2031

Source: ACIL Allen

5.2.3 Houses with pools or spas

As mentioned in Section 4.2, the proposed WoH requirements would apply to pool and spa pumps. Two key inputs are required to account for the impact of these new requirements in the economic modelling:

- An estimate of the proportion of new detached dwellings that are fitted with pools or spas at the time of construction and projections about how this is expected to change over the period of analysis. Attached dwellings/townhouses and apartments are excluded from these estimates as any pools/spas installed during construction form part of common areas (which are regulated separately under Section J of the NCC) and hence are not included in the modelling.
- Estimates about the costs and benefits associated with dwellings with pools under NCC 2022.

Notably, given the complexity of simulating multiple baselines and compliance cases for houses with pools only, with spas only, and with pools and spas (which resulted in limited permutations modelled by EES for the RIS), all of these houses are simply treated as houses with pools in the modelling. This means that houses with pools only, with spas only, and with pools and spas are assumed to receive the same costs and benefits from NCC 2022. We are of the view that this does not have a material impact on the modelling, as we expect the number of new houses with a spa only or with a pool and a spa to be very small — currently the only data available in this respect is from BASIX in NSW (see Table 5.5), which supports this assumption.

Table 5.5 Proportion of new dwellings with pools and spas in NSW (based on BASIX data from July 2017 to June 2020)

	Proportion
Pools only, no spas	4.09%
Spas only, no pools	0.10%
Pools and spas	0.46%
Total proportion of new buildings with a pool, spa or pool and spa	**4.65%**

Note: Pools and spas as common areas are excluded.
Source: NSW Department of Planning, Industry and Environment.

Besides BASIX data for NSW, there is no other dataset available on the current number of *new* dwellings with pools installed at the time of construction. Given this, we developed estimates to use in the RIS using the following approach:

1. We used statistics about the *total* number of houses (new and existing) with pools and spas and the total number of dwellings in each jurisdiction (outlined in Table 5.6) to estimate a ratio of pools per dwelling by jurisdiction.
2. We used this ratio to estimate the likelihood of a dwelling in each jurisdiction having a pool, compared to NSW, and scaled the estimates of the proportion of new houses with pools in NSW in Table 5.5 up or down for other jurisdictions according to this ratio.

The estimated proportion of new dwellings with pools or spas by jurisdiction is outlined in Table 5.7. It has been assumed that this proportion remains constant over the analysis period. This table also includes an estimate of how these proportions translate into the number of pools installed in new buildings in 2022.

Table 5.6 Number of pools[a] and dwellings by jurisdiction

	NSW	NT	QLD	SA	TAS	VIC	WA	ACT
Total number of pools installed in 2019 [a]								
Inground pools	428,206	38,754	450,087	84,512	8,451	201,892	220,955	12,976
Above grounds pools	24,000	2,400	24,800	4,800	800	11,200	12,000	800
Spas	26,000	1,040	12,480	10,400	1,040	41,600	10,400	1,040
Total	**478,206**	**42,194**	**487,367**	**99,712**	**10,291**	**254,692**	**243,355**	**14,816**
Number of dwellings [b]	3,282,500	86,500	2,122,800	796,000	249,700	2,759,600	1,125,000	180,800
Pools per dwelling ratio	0.15	0.49	0.23	0.13	0.04	0.09	0.22	0.08

[a] Includes pools installed in new and existing dwellings.
[b] As at December 2020, sourced from ABS.
[c] Spas treated as pools as noted in the text above.
Source: ABS, Swimming Pool & Spa Association of Australia and ACIL Allen.

Table 5.7 Estimated proportion and number of new detached dwellings fitted with pools and spas at time of construction by jurisdiction

	NSW [a]	NT	QLD	SA	TAS	VIC	WA	ACT
Proportion of new dwellings with pools and spas								
Pools only, no spas	4.1%	13.7%	6.4%	3.5%	1.2%	2.6%	6.1%	2.3%
Spas only, no pools	0.1%	0.3%	0.2%	0.1%	0.0%	0.1%	0.1%	0.1%
Pools and spas	0.5%	1.5%	0.7%	0.4%	0.1%	0.3%	0.7%	0.3%
Total	**4.7%**	**15.6%**	**7.3%**	**4.0%**	**1.3%**	**2.9%**	**6.9%**	**2.6%**
Number of new detached dwellings in 2022 with pools and spas								
Pools only, no spas	778	76	1,467	263	26	685	1,126	25
Spas only, no pools	19	2	36	6	1	17	28	1
Pools and spas	88	9	165	30	3	77	127	3
Total	**885**	**86**	**1,668**	**299**	**29**	**778**	**1,280**	**29**

[a] Reflects actual data in Table 5.5. Totals may not add up due to rounding.
Source: ACIL Allen.

5.3 Impact assessment

5.3.1 Building sample and aggregation

The CBA was conducted using a ‘bottom-up’ approach that:

— first estimates the benefits (and costs) of the new proposed requirements at the individual dwelling level for representative Class 1 and Class 2 dwellings in different climate zones across each jurisdiction[104]

— aggregates these representative dwellings to climate zones, states and territories, and then to a national level.

The impacts of the proposed policy options on energy consumption and construction costs at the individual household level were modelled by EES. These impacts were provided to ACIL Allen for a single representative Class 1[105] and Class 2 dwelling in each of the climate zones and jurisdictions outlined in Table 5.8 and Table 5.9.

[104] The impacts on Class 4 parts of buildings has not been estimated in the RIS due to very low construction activity in this segment (the CSIRO Australian Housing Data portal shows less than 400 of these buildings were built between 2016 and 2022).

[105] Attached and detached Class 1 dwellings were not separately modelled by EES; ACIL Allen was provided with impact data for a ‘generic’ Class 1 dwelling. Given this, our analysis does not provide specific details about the impacts of the proposed provisions on attached and detached Class 1 dwellings.

Table 5.8 Jurisdictions and climate zones where a representative Class 1 dwelling was modelled by EES

Jurisdiction	NCC climate zone	NatHERS climate zone	Jurisdiction	NCC climate zone	NatHERS climate zone
NSW	2	10	QLD	5	28
NSW	4	27	SA	4	27
NSW	5	28	SA	5	16
NSW	6	60	SA	6	60
NSW	7	24	WA	1	32
NSW	8	69	WA	3	3
VIC	4	27	WA	4	27
VIC	6	60	WA	5	13
VIC	7	24	WA	6	60
VIC	8	69	TAS	7	26
QLD	1	32	NT	1	1
QLD	2	10	NT	3	3
QLD	3	3	ACT	7	24

Source: EES.

Table 5.9 Jurisdictions and climate zones where a representative Class 2 dwelling was modelled by EES

Jurisdiction	NCC climate zone	NatHERS climate zone	Jurisdiction	NCC climate zone	NatHERS climate zone
NSW	2	10	QLD	2	10
NSW	4	27	QLD	5	56
NSW	5	56	SA	5	16
NSW	6	21	WA	5	13
NSW	7	24	TAS	7	26
VIC	6	21	NT	1	1
VIC	7	24	ACT	7	24
QLD	1	32			

Source: EES.

The additional costs and benefits (in terms of changes in energy consumption) associated with the proposed policy options for individual dwellings were modelled using a two-step approach.

1. First, TIC estimated the costs and benefits of increasing the building shell performance level from 6 to 7 stars in a sample of dwellings (which included a mix of one and two-storey houses, detached and semi-detached houses, an apartment and variations in size and floor type) across a variety of locations. More information about the methodology and results of this modelling can be found in TIC's report '*Cost and Benefits of upgrading building fabric from 6 to 7 stars*'.
2. Then, EES used TIC's modelling results to model the overall impact of the WoH provisions (including the increase from 6 to 7 stars) on one representative Class 1 and Class 2 dwelling in each of the climate zones and jurisdictions outlined in Table 5.8 and Table 5.9. To calculate the energy flows for each of these representative dwellings, EES selected a single Class 1 and Class 2 dwelling in each jurisdiction from TIC's modelling to generate heating and cooling load inputs into the WoH model.106 The WoH costs for these representative dwellings include the building shell upgrade costs sourced from TIC, and equipment upgrade costs. EES calculated the building shell upgrade costs for each representative dwelling as a weighted average cost of the various dwellings modelled by TIC (i.e. the costs of increasing from 6 to 7 stars for the representative dwellings provided by EES are effectively the costs of a 'composite house' which reflects the weighted average of the houses in TIC's sample).

To estimate the costs and energy flows for the WoH provisions EE modelled a representative sample of equipment options which included six heater types (including no heating) combined with four cooler types (including no cooling) and seven water heater types. A total of 77 combinations were modelled, noting that not all heater types were combined with all cooler types. In total, ten heater/cooler combinations were combined with each of the seven water heater types[107]. EES then estimated the propensity of each of these equipment combinations in new dwellings to produce a composite dwelling by each jurisdiction and climate zone modelled.

Notably, in response to comments received during consultation, EES and TIC undertook a detailed review of the technical modelling underpinning the RIS. As a result of this process, a range of technical modifications to both the method and underlying assumptions underpinning the modelling of benefits and costs were undertaken. The key changes to the technical modelling are the following.

1. *Optimisation of expected design solution* — analysis revealed that the expected response of the building industry to the proposed regulations that was used in the CRIS analysis was overly simplistic and failed to deliver the most optimal results. A revised design optimisation process was developed that considered a much broader range of cost effective compliance options, which is considered to be more representative of the workings of the industry.
2. *Amendments to the assumed level of STC credits for PVs* — accounting for STC credits in relation to PV installations had been calculated for the CRIS based on a deemed lifetime of 4

[106] EES notes that this approach is valid because the total of the heating and cooling loads calculated by TIC are very similar for all 7 star dwellings. Depending on the thermal mass of the wall and floor types assessed, there can be some variation in the proportion of heating compared to cooling in the moderate climates. This is not expected to be significant, particularly where reverse cycle heating/cooling is used.

[107] Details of the exact combinations modelled can be found in EES's report '*NCC 2022 Update - Whole of Home Component'.*

years (i.e. the expected average credit period over the lifetime of the regulations 2022-2031). The technical modelling was changed to reflect annual, rather average credits.

3. *Amendments to the assumed propensity of gas heating in Victoria under the baseline* — the assumed propensity of gas heating in new Victorian houses under the baseline was amended (increased) to better align with estimates provided by the Victorian Department of Environment, Land, Water and Planning (DELWP).
4. *Factoring in the impact of the outdoor living area (OLA) provisions of NCC 2019* — in the original CRIS analysis, the impact of OLA provisions of NCC 2019 were not factored into the calculations. These provisions reduce the cost of compliance for those dwellings that include an OLA (NCC climate zones 1 and 2 in Qld, NT and WA). This omission was remedied for the Decision RIS analysis.
5. *Factoring in the impact of the NCC 2022 elemental provisions* — the proposed elemental provisions are based on achieving close to a 7-star performance in each climate zone. The newly refined elemental provisions are expected to lower costs in 2022 for the 20 per cent of dwellings (nationally) that use the elemental provisions. These savings have now been factored into the Decision RIS analysis.
6. *Adjustments to assumed propensity and capacity of PVs installed into Class 1 base case dwellings* — the estimates of the propensity of base case Class 1 dwellings that were fitted with PVs as well as the average capacity of those PV installations was updated as per discussion in Section 5.2.1.

More information about the changes to the technical modelling for the Decision RIS can be found on TIC's report '*DRIS Update – Companion Technical Documentation*'[108] and more details about the methodology used by EES to estimate the impacts of the WoH provisions on individual households can be found in EES's report '*NCC 2022 Update - Whole-of-Home Component'.*

The representative dwellings modelled by EES were aggregated by allocating the projected number of new dwellings by class by jurisdiction (outlined in Section 5.2.2) to different climate zones within jurisdictions using data from CSIRO's Australian Housing Dataset on the proportion of new buildings built by climate zone by state (outlined in Table 5.10 and Table 5.11).

Notably, the cells shaded in Table 5.10 and Table 5.11 highlight climate zones not modelled by EES due to small numbers of dwellings built in these locations. As such, to account for the dwellings built in these locations it was assumed that dwellings in these climate zones would experience equivalent costs and benefits as those in the closest climate zone modelled in the same jurisdiction. For instance:

— Class 1 dwellings currently built in climate zones 4, 5 and 6 in the ACT are assumed to experience equivalent costs and benefits as those in climate zone 7
— Class 2 dwellings currently built in climate zone 8 in NSW are assumed to experience equivalent costs and benefits as those in climate zone 7

[108] TIC 2022, *ABCB NCC 2022 – Energy Efficiency Provisions DRIS Update – Companion Technical Documentation*.

— Class 2 dwellings currently built in climate zone 3 in Queensland are assumed to experience equivalent costs and benefits as those in climate zone 2.

Table 5.10 Proportion of Class 1 dwellings built by state by climate zone from 2016 to 2021

NCC Climate Zone	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
1 - High humidity summer, warm winter			83.90%	11.22%				2.19%
2 - Warm humid summer, mild winter		7.05%		84.07%	**0.01%**			
3 - Hot dry summer, warm winter			16.10%	0.49%				0.40%
4 - Hot dry summer, cool winter	**0.03%**	3.80%			13.07%		2.08%	6.50%
5 - Warm temperate	**0.03%**	34.85%		4.20%	80.17%			86.17%
6 - Mild temperate	**0.01%**	49.05%		**0.02%**	6.75%		87.37%	4.73%
7 - Cool temperate	99.93%	5.03%				99.96%	10.51%	**0.01%**
8 - Alpine		0.22%				**0.04%**	0.03%	

Note: shaded cells highlight climate zones not modelled by EES due to small numbers of dwellings built in these locations.
Source: CSIRO Australian Housing Dataset.

Table 5.11 Proportion of Class 2 dwellings built by state by climate zone from 2016 to 2021

NCC Climate Zone	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
1 - High humidity summer, warm winter			96.97%	2.27%				0.11%
2 - Warm humid summer, mild winter		1.02%		97.21%				
3 - Hot dry summer, warm winter			**3.03%**	**0.16%**				
4 - Hot dry summer, cool winter		0.23%			**0.25%**		**0.03%**	
5 - Warm temperate	**0.93%**	74.56%		0.37%	99.66%		**0.04%**	99.74%
6 - Mild temperate		23.77%			**0.08%**		99.59%	**0.16%**
7 - Cool temperate	99.07%	0.40%				100.00%	0.33%	
8 - Alpine		**0.02%**						

Note: shaded cells highlight climate zones not modelled by EES due to small numbers of dwellings built in these locations.
Source: CSIRO Australian Housing Dataset.

Table 5.12 Assumptions used in the impact analysis regarding the proportion of Class 1 and Class 2 dwellings that will be built by state by climate zone from 2022 to 2031

NCC Climate Zone	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
Class 1								
1 - High humidity summer, warm winter	-	-	84.0%	11.2%	-	-	-	2.2%
2 - Warm humid summer, mild winter	-	7.1%	-	84.1%	-	-	-	-
3 - Hot dry summer, warm winter	-	-	16.0%	0.5%	-	-	-	0.4%
4 - Hot dry summer, cool winter	-	3.8%	-	-	13.1%	-	2.1%	6.5%
5 - Warm temperate	-	34.9%	-	4.2%	80.2%	-	-	86.2%
6 - Mild temperate	-	49.1%	-	-	6.8%	-	87.4%	4.7%
7 - Cool temperate	100%	5.0%	-	-	-	100%	10.5%	-
8 - Alpine	-	0.2%	-	-	-	-	-	-
Class 2								
1 - High humidity summer, warm winter	-	-	100%	2.3%	-	-	-	0.2%
2 - Warm humid summer, mild winter	-	1.0%	-	97.3%	-	-	-	-
3 - Hot dry summer, warm winter	-	-	-	-	-	-	-	-
4 - Hot dry summer, cool winter	-	0.2%	-	-	-	-	-	-
5 - Warm temperate	-	74.6%	-	0.4%	100%	-	-	99.8%
6 - Mild temperate	-	23.8%	-	-	-	-	99.6%	-
7 - Cool temperate	100%	0.4%	-	-	-	100%	0.4%	-
8 - Alpine	-	-	-	-	-	-	-	-

Note: Totals may not add up due to rounding.
Source: ACIL Allen.

5.3.2 Treatment of refurbishments

There are several difficulties related to the analysis of the impacts of the proposed increased energy efficiency requirements on the refurbishment of existing buildings.

— The application of the NCC to refurbishments is covered in state/territory legislation, so individual jurisdictions can apply the NCC to refurbishments as rigorously as they see fit.

— The extent to which refurbishments comply with the NCC will vary by project (i.e. it is unknown what proportion of refurbishments will need to comply with the new NCC requirements and to what extent). Furthermore, at this stage it is still unclear if, and how, the proposed WoH requirements would apply to refurbishments.[109]

— Many existing buildings may be unable to comply with the NCC provisions, particularly the new WoH provisions.

— The costs of complying with the new energy efficiency requirements in existing houses may differ to new builds given the inherent variability of refurbishments.

The CRIS asked for feedback from stakeholders about the treatment of refurbishments with respect to the WoH provisions. In particular, the CRIS asked whether it is practical to apply this proposal to refurbishments (and if so, how) and whether the costs and benefits of applying the WoH provisions to refurbishments would be broadly similar to those experienced by new dwellings.

The majority of stakeholders who provided a submission did not answer the practicality question (36 per cent) and a further 21 per cent said they were not sure whether it is practical to apply the WoH proposal to refurbishments. Of the remaining submissions, 28 per cent think that it is practical to apply the WoH proposal to refurbishments and 15 per cent think it is not. In terms of costs and benefits of the WoH provisions:

— 11 per cent of submissions noted that the cost of applying the WoH proposal to renovations would be broadly similar to the cost incurred for new dwellings, 27 per cent think costs would be higher and 3 per cent think costs would be lower. The remainder of submissions did not answer this question or were unsure of the answer

— 17 per cent of submissions noted that the benefits of applying the WoH proposal to renovations would be broadly similar to the benefits experienced by new dwellings, 13 per cent think benefits would be higher and 14 per cent think benefits would be lower. The remainder of submissions did not answer this question or were unsure of the answer.

The HIA argues in its submission that the NCC should be used as a key part of the solution for existing housing by setting a minimum DTS benchmark for all major renovations. However, they suggest that refurbishments and renovations should be completely exempt from the WoH provisions due to their complexities.

The submissions from Renew and the New England Greens argue that it is practical to apply the WoH proposal to refurbishments as these requirements can likely be achieved at low cost through installation of onsite PV and/or efficient equipment and there is no clear barrier to doing this in a renovation. Renew also argues that the costs of applying the WoH proposal to renovations would be broadly similar to the cost incurred for new dwellings but the benefits would be higher.

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[109] For instance, the WoH/equipment components for renovations in the BASIX Alterations and Additions tool do not have any energy performance requirements. Users need to select the type of hot water system and the selection will form part of the BASIX requirement. BASIX currently prescribes 40 per cent of new or altered lighting fixtures to be fitted with energy efficient lights. If there is a pool being installed, users need to specify pool heating. Depending on the selection, BASIX will prescribe the need for pool/spa covers or a pool pump timer.

In contrast, the SCA argues that the costs of applying the WoH proposals to renovations of Class 2 buildings are higher than for new buildings and the benefits lower than for new buildings, while the ENA suggests that it is not practical to apply the who provisions to refurbishments, the costs of doing so would be higher in renovations than new dwellings and the benefits for renovations will be higher than for new dwellings.

In their joint submission, PCA, ASBEC, GBCA and EEC suggest that it is practical to apply WoH provisions to refurbishments, the benefits of doing so would be higher than the benefits received by new dwellings, but are unsure about whether the costs incurred by refurbishments would be similar to those incurred for new dwellings. This submission also notes that, while deep retrofitting of homes is not yet mainstream, a number of demonstration projects are showing how effective and affordable such retrofits could be if impediments can be overcome.

With respect to the application of the WoH proposal to refurbishments, EBAA notes that care is needed to not deteriorate the performance of older buildings through modernisation. EBAA suggests that an important first step for renovations is determining whether changes to the building's fabric are needed and whether the building is able to be upgraded to work well passively and not require mechanical ventilation and conditioning. If so, they argue that this would be a better outcome.

While a range of views were provided during consultation, no new information was received that could help overcome the complexities related to the analysis of the impacts of the proposed WoH on the refurbishment of existing buildings in the Decision RIS. Furthermore, at this stage it is still unclear if, and how, the proposed WoH requirements would apply to refurbishments in individual jurisdictions.

Given this, refurbishments continue to be excluded from the impact analysis in the Decision RIS.

5.3.3 Thermal bridging

Thermal bridging is a localised weakness or discontinuity in the thermal envelope of a building that occurs when there is either a break in the insulation, less insulation or the insulation is penetrated by an element with a higher thermal conductivity. It affects in-service performance, producing heat loss and cold spots that can lead to a build-up of condensation and promote mould growth.

Currently, the NatHERS thermal simulation tools used for the majority of building approvals do not take into account the added heat losses and heat gains due to thermal bridging and the current version of the NCC does not have provisions to fully account for thermal bridging in the thermal calculations for residential buildings. This results in an energy efficiency performance gap where new buildings currently rated at 6 stars in reality perform to a lesser standard due to heat leakage. TIC[110] estimates that the impact of thermal bridging on the energy efficiency of a dwelling is:

- in timber framed buildings, a reduction in NatHERS ratings of between 0.1 to 0.6 stars
- in steel framed buildings, a loss of performance of between 0.7 and 1.5 NatHERS stars more than the impact of timber frames (impacts are highest in cooler climates).

[110] Tony Isaacs Consulting (TIC) 2021a, *DTS Elemental Provisions for NCC 2022*, Draft.

A one-star reduction is, on average, across most NatHERS climate zones, at least a 15 per cent reduction in a dwelling's energy efficiency.[111]

The proposed changes to the NCC 2022 include provisions to account for heat leakage through thermal bridges when calculating insulation requirements. These provisions will only apply to steel frame dwellings. These mitigation measures have been designed to ensure that dwellings with steel frames achieve a similar performance to timber-framed dwellings.

There are several implications of these changes for the analysis:

— The thermal bridging changes in NCC 2022 will result in compliance costs that are *additional* to the costs of moving the thermal shell from 6 to 7 stars (in effect, these costs will be incurred to get buildings to perform as 'true' 6 star buildings).
— Leaving aside the stringency increase from 6 to 7 stars, the thermal bridging changes in NCC 2022 will materialise the benefits of the 6 star rating that were projected in the 2009 RIS[112] for an increase in energy efficiency from 5 to 6 stars in 2009.
— Given that the NCC 2022 only includes provisions to mitigate thermal bridging in steel frame buildings, the performance gap discussed above will continue in timber frame buildings. The energy flows for timber buildings provided by EES do not include an adjustment for this gap and hence neither does the RIS.

The CRIS accounted for the costs of addressing thermal bridging, but not the benefits. This approach was based on the argument that the 2009 residential 6 star RIS already accounted for the benefits of achieving a 'true' 6 star rating (i.e. the 2009 RIS assumed that buildings would perform as 6 stars), but did not account for thermal bridging or the costs associated with addressing this issue.

Several stakeholders commented about thermal bridging during consultation. PCA, ASBEC, GBCA, EEC, Renew, New England Greens and another submission argue that the benefits of the thermal bridging provisions should be included in the impact analysis if the costs of these provisions are included. One submission also noted that thermal bridging should be used for any construction method based on clear performance benchmarks and that the methods of analysis should not favour one material over another but should establish a level playing field for all building materials.

HIA has a range of concerns (both technical and from the CRIS perspective) with the proposed introduction of thermal bridging requirements. The main concern relevant to the CRIS is that it does not provide an assessment of the impacts that the proposed thermal bridging provisions would have on the steel framing industry (HIA argues that builders will re-consider their choice of framing system if one would face additional costs over the other).

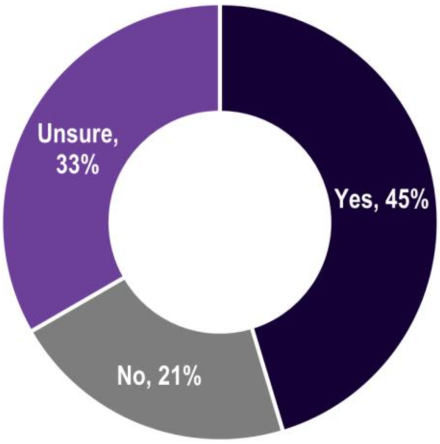
[111] Tony Isaacs Consulting (TIC) 2021b, *Evaluating the impact of thermal bridging on energy savings predicted for the NCC 2022 RIS*, May.

[112] Centre for International Economics (CIE) 2009, *Final Regulation Impact Statement for residential buildings (Class 1, 2, 4 and 10 buildings) - Proposal to revise energy efficiency requirements of the Building Code of Australia for residential buildings*, prepared for the Australian Building Codes Board, December

BlueScope Steel argues that thermal bridging mitigation measures should not be introduced for timber or steel framed buildings as 'this has been found to create significant cost with limited benefit for steel framing beyond the current thermal break requirements that already exist'[113]. This submission also noted that the implied star rating impacts and assumptions from thermal bridging differ considerably between analysis by TIC and CSIRO and suggest that this results in fabric costs being underestimated.

In contrast with BlueScope Steel's view regarding timber framed buildings, 45 per cent of the submissions indicated that thermal bridging in timber framed buildings should be incorporated in the analysis (see Figure 5.6).

Figure 5.6 Proportion of submissions that indicated that thermal bridging in timber-framed buildings should be incorporated in the analysis



Note: Responses refer to question 11, Should thermal bridging in timber-framed buildings be incorporated in the analysis? Chart excludes submissions that did not answer this question. 75 submissions answered this question.
Source: Citizen Space submission data.

In its submission, NASH argues that the CRIS does not discuss thermal bridging mitigation costs or the assumptions used to calculate these costs. This submission also argues that multiple reports show widely varying differences in star ratings when thermal bridging is included and argues that these differences need to be reconciled before reliable measures and costs can be determined. NASH also notes that cost estimates for some thermal bridging mitigation products cannot be made as the products do not yet exist (for instance, Class 3&4 continuous insulation sheaths).

In response to this feedback:

— To ensure that the principle of symmetry is applied to the proposed thermal bridging mitigation provisions, the benefits of thermal bridging measures have been included in the cost benefit analysis in this Decision RIS. However, it is important to note that the thermal bridging benefits

113 BlueScope Steel submission, answer to question 6.

were effectively already counted in the 2009 6 star RIS, which had the effect of overstating the net impacts of that regulatory change. [114]

— The ABCB has commissioned the University of Wollongong (UoW) to review the NCC technical provisions based on feedback received through the public comment draft process. The result of this review supported the inclusion of provisions to mitigate the impact of thermal bridging, while suggesting adjustments to them. Based on both the review and feedback received through consultation, the provisions were updated to delete the option of using thermal break strips, facilitate DTS solutions in climate zones 6 to 8 that manage condensation risks, and delete references to calculation methods in unsuitable applications.

— The potential impacts of the proposed thermal bridging mitigation provisions on the steel framing industry, and the construction industry broadly, are discussed qualitatively in Chapter 9. The range of non-energy benefits from addressing thermal bridging (e.g. reductions in condensation on internal) are also discussed qualitatively in the Decision RIS.

— We note that the CRIS includes information about the thermal bridging mitigation costs for both Class 1 and 2 steel frame buildings in Section 4.4.4 and refers the reader seeking additional information about the calculation of these costs to TIC's report *Evaluating the impact of thermal bridging on energy savings predicted for the NCC 2022 RIS*.

5.3.4 Difficult blocks

During the NCC 2022 development process, industry stakeholders advised the ABCB that certain blocks have characteristics that create difficulties for some construction methods to demonstrate compliance via the NatHERS DTS pathway for Class 1 buildings.[115] To provide additional information on this issue, the ABCB commissioned:

— AECOM to undertake an analysis of the additional costs (for insulation, glazing upgrades, etc.) to achieve an improvement from a 6-star to a 7-star rating on a difficult block, when compared with achieving an improvement from a 6-star to a 7-star rating on a 'standard' non-difficult block.[116] This analysis provided cost estimates for a selection of attached and detached dwellings in a number of locations and climate zones for blocks that:
  – are small and have challenging proportions
  – have poor orientation
  – have problematic topography.

[114] Notably, even when the 2009 RIS modelled the benefits of achieving a 'true' 6 star rating, the Net Present Value (NPV) of increasing from 5 to 6 stars was negative (-$259 million, with a BCR of 0.88) at 7 per cent discount rate (the recommended central discount rate by OBPR). Should the 'true' benefits of this increase have been modelled (i.e. the energy savings likely to be achieved when thermal bridging was accounted for , which would be lower) or the costs of mitigating thermal bridging accounted for (and hence achieving a 'true' 6 star rating), the NPV and BCR of the policy would have been even lower.

[115] These characteristics include (amongst other), small area and challenging proportions, poor orientation, and problematic topography.

[116] For additional details of this analysis please refer to AECOM 2020, *Difficult Blocks – Final Report Revision 2,* September.

The estimated changes in compliance costs (from 6 to 7 stars) for a Class 1 dwelling built on a small and narrow difficult block, by climate zone, are outlined in Section 5.4.3.[117]

— SGS Economics & Planning to estimate the proportion of residential lots that fall within the small and narrow lot categories[118] across Brisbane, Melbourne and Sydney (which make up about ¾ of residential development in Australia).[119] Based on SGS's findings, we estimated the proportion of Class 1 dwellings that are built on small and narrow difficult blocks across jurisdictions. This is shown in Table 5.13 (the proportions of difficult blocks in this table are assumed to remain constant over the analysis period). Notably, these proportions were calculated by assuming that:
  – the proportion of difficult blocks in other capital cities is an average of the proportion of difficult blocks in Brisbane, Melbourne and Sydney
  – SGS's estimated proportions of difficult blocks in capital cities apply to the whole of the state (e.g. the proportion of difficult blocks for the rest of Queensland is the same as the proportion of difficult blocks in Brisbane).

Using the information from the sources outlined above, the CRIS included additional compliance costs stemming from the proposed changes in thermal requirements for Class 1 dwellings built on difficult blocks. Given the information available, this analysis only included the additional costs of compliance associated with difficult blocks that are small and narrow. These additional costs are only incurred by Class 1 dwellings that are currently built at 6 stars under the BAU (i.e. a dwelling already built at 7 stars on a difficult block under the BAU would not experience these additional costs). More information about these costs is provided in Section 6.1.

Table 5.13 Proportion of small and narrow blocks by state

State	Proportion of small and narrow blocks
NSW	8.4%
QLD	1.8%
VIC	7.3%
SA	5.8%
WA	5.8%
TAS	5.8%
NT	5.8%
ACT	5.8%

Source: ACIL Allen based on SGS Economics & Planning 2021, Australian Cities Residential Lot Analysis Final Memo, prepared for the Australian Building Codes Board, January.

[117] Importantly, AECOM did not provide estimates for all dwellings across all locations for all of the types of difficult blocks. Any data gaps in this analysis were filled with assumptions provided by the ABCB.

[118] Small lots are defined as lots of less than 300m^2 and narrow lots are defined as lots where the length/width ratio is above 3:1.

[119] For additional details of this analysis please refer to SGS Economics & Planning 2021, *Australian Cities Residential Lot Analysis Final Memo*, prepared for the Australian Building Codes Board, January.

During consultation, stakeholders provided different views about the treatment of difficult and shaded blocks in the CRIS analysis. In the joint submission by the PCA, ASBEC, GBCA and EEC these stakeholders argue that some of the costs for difficult and shaded blocks are too high and that, while there are likely to be additional construction costs on difficult blocks, this will also be true in the base case, and this will likely impact the price of various blocks.

It is important to note that the cost estimates for difficult blocks used in the CRIS (and Decision RIS) measure the marginal costs of building a 7 star house on a difficult block compared to building a 6 star house on a difficult block (that is, the analysis compares a difficult 6 star house to a difficult 7 star house, therefore accounting for the fact that the baseline is also a difficult block).

In terms of reductions in land values, broadly, land prices reflect a block’s location, structural attributes, land rates and land use. This means that higher construction costs (e.g. due to the block’s slope) would be reflected in lower land values (all other things being equal). However, a reduction in land value for difficult blocks would rely on understanding the limitations the land places on the design of a 7 star house relative to a 6 star house at purchase, and it is unclear whether this is the case.

In contrast to the joint submission’s view, the HIA and EBAA suggest that the costs associated with difficult blocks are underestimated in the CRIS. In particular, the HIA argues that the percentage of small and narrow blocks estimated by SGS are highly conservative given that the median lot size has decreased significantly over time and so narrow blocks are likely to increase over time (and so should the estimated costs for difficult blocks). HIA suggest that a more representative assumption would be that 10-15 per cent of all new housing sites in all states are treated as difficult blocks. EBAA argues that the average site area of new house approvals has decreased significantly over the last 15 years but that the average floor area of new houses approved in Australian capital cities continues to increase.

With respect to the issues of floor area and site area of new houses, it is noted that Australian Bureau of Statistics’ (ABS) data[120] shows that:

— the average site area[121] of new houses in Australian capital cities has decreased by 22 per cent (135m²) over the 15 year period from 2005-06 to 2019-20, from 602m² in 2005-06 to 467 square metres in 2019-20
— across the five largest states (NSW, Victoria, Queensland, South Australia and WA), average site areas for house approvals trended downwards in all capital cities over the period from 2005-06 to 2019-20, resulting in increased housing density across the capitals
— the average floor area[122] of new houses approved in Australian capital cities has remained relatively unchanged over the 15 years between 2005-06 and 2019-20, ranging between 234m² and 248m², an increase of 14 square meters (6 per cent).

[120] Australian Bureau of Statistics (ABS) 2020, Australians building houses on smaller blocks, September, https://www.abs.gov.au/articles/australians-building-houses-smaller-blocks, accessed 17 January 2022.

[121] The ABS define the site area of a house approval as a measure of the site area of the block of land the house will be situated on and is measured in metres squared (m²). This is also known as the 'lot size' or 'block size'.

[122] The floor area of a house is defined by the ABS as the expected quantity of useable space within the dwelling (including attachments) at its completion. This figure is measured in metres squared (m²) as reported

These trends combined indicate that Australians are building slightly larger houses in smaller lots.

Notably, the analysis conducted by SGS which estimates the proportion of difficult blocks used in the CRIS reflects the trends in smaller lots in certain areas. For instance, their analysis notes that urban inner core areas in Sydney have, on average, a higher proportion of small lots due to the limited amount of developable land and historical development trends (e.g. in places like Botany, infill development often occurs on narrow lots, where there are less room for structural changes). To account for the proportion of small lots in different urban areas (established, growth and inner core) and the amount of development activity within these areas, the analysis in the CRIS used a weighted average of the proportion of difficult blocks by area and the dwellings approvals by area in 2020. In this way, the proportions in the CRIS appropriately account for areas with high proportion of difficult blocks but low levels of new development, and areas with low proportion of difficult blocks but high levels of development.

Submission ANON-7GZH-JXVR-A argues that there should be no special treatment for difficult blocks (or shaded blocks).In this respect, it is important to note that under the NCC 2022 provisions, difficult blocks are not treated differently. It is only in the impact analysis in the CRIS that these blocks are assumed to incur some additional costs to reflect the additional outlays that blocks with certain challenging characteristics would have to incur to comply with the proposed requirements.

After reflecting on the feedback received about difficult blocks and further consideration of the approach taken to analyse these blocks in the CRIS, it has been concluded that the approach taken in the CRIS appropriately balances:

— the existing evidence on the trends in block sizes and building approvals
— the existing evidence on the marginal costs of building a 7 star home rather than a 6 star home on a difficult block
— the uncertainties and complexities surrounding the characteristics and prevalence of these blocks.

In light of this, the analytical approach for difficult blocks has been maintained in the Decision RIS.

5.3.5 Shaded blocks

EES' modelling estimated that a proportion of Class 1 buildings across most climate zones and jurisdictions would require solar PVs to be installed to meet the WoH requirements under NCC 2022, more so under Option A. In reality, some of these buildings are unlikely to be able to install solar PVs due to issues of overshadowing. Buildings with overshadowing issues which cannot effectively install solar PVs can still meet the NCC 2022 requirements (under both Option A and B) through:

— a higher performance building shell (above 7 stars)
— high efficiency equipment
— a combination of the above.

by the council or private certifier on the building approval record. The boundary of the recorded floor area of a dwelling is delineated by the external perimeter of the dwelling's exterior walls. This excludes non-enclosed structures attached outside the floor area boundary such as verandahs and carports.

As noted before, different levels of building shell performance (above 7 stars) were not modelled by EES for the RIS. However, they did model a pathway where buildings comply with the new requirements through high efficiency equipment (referred to as the 'all equipment upgrade pathway'). Overall, this upgrade pathway results in higher compliance costs when compared to the other upgrade pathways modelled by EES[123] due to the higher cost of the more efficient equipment needed to meet the proposed requirements (more details about the assumed upgrade pathways for different buildings are provided in Section 5.3.6).

There is no data currently available on the proportion of shaded blocks across different locations, however it is acknowledged that this issue is more likely to affect infill developments. A broad indication of the magnitude of this issue is provided by a study by the City of Melbourne that surveyed 212 residents to investigate awareness, attitudes, needs and barriers relating to rooftop solar PV systems. In this study, 8 per cent of residents noted overshadowing from taller buildings as a barrier preventing them from installing rooftop solar.[124]

For the purposes of the CRIS, it was agreed with the ABCB that the economic modelling would assume that no blocks are shaded, given:

— the lack of data about the magnitude of the overshadowing issues for new residential buildings
— the fact that this issue is likely to affect only infill developments
— the results of EES's modelling that show that only a relatively small proportion of buildings will adopt an upgrade pathway that involves the installation of solar PV.

No evidence was provided during consultation to support a change to this assumption, so the approach to shaded blocks in the RIS remains unchanged. While this effectively assumes that all buildings can install solar PVs to comply with the NCC 2022 without risks of overshadowing, this scenario is unlikely.

[123] Broadly, the upgrade pathways modelled by EES for buildings without solar PV in the BAU are: 1) retaining the BAU equipment selection and applying as much solar PV as is required to meet the requirements; 2) altering the equipment selection only (i.e. not adding solar PV); 3) altering the equipment selection plus adding as much solar PV as is required to meet the requirements. These are discussed in more detail in Section 5.3.6

[124] City of Melbourne 2015, *Community Attitudes and Barriers to Rooftop Solar Final report*, August.

5.3.6 Assumed response to NCC 2022: upgrade pathways

There are different upgrade pathways a builder can take to comply with the new requirements in the NCC 2022, depending on the BAU characteristics. For instance, a Class 1 building that is built as 6 stars with solar PV installed under the baseline would need a different upgrade to meet NCC 2022 than a building that is built without any solar PV installed under the baseline or that is built at 7 stars with solar PV. This means that, in essence, the costs and benefits of the proposed energy efficiency requirements will be different depending on:

— a building's 'starting point' or characteristics under the BAU

— the upgrade pathway that this building is assumed to take to meet the NCC 2022 requirements.

While in reality there are multiple combinations of starting points and upgrade pathways for buildings, for modelling purposes, simplifying assumptions were required. These assumptions are summarised in Table 5.14 and described in more detail in the following sections.

Table 5.14 Modelled combinations of building characteristics in the BAU and assumed upgrade pathways under NCC 2022

Building characteristics in the BAU				Assumed upgrade pathway		
Baseline star rating	**Pool/spa?**	**Difficult block?**	**Solar PV in baseline?**	**Upgrade pathway**	**Additional cost for thermal bridging mitigation?**	**Additional difficult block cost?**
CLASS 1						
6 stars	No	No	No	Upgrade shell from 6 to 7 stars and meet the WoH requirements through the lowest cost upgrade pathway	Yes, only for steel framed buildings	No
6 stars	No	Yes	No	Upgrade shell from 6 to 7 stars and meet the WoH requirements through the lowest cost upgrade pathway	Yes, only for steel framed buildings	Yes
6 stars	No	No	Yes	Upgrade shell from 6 to 7 stars, retain solar PV as per BAU and meet the WoH requirements through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	No
6 stars	No	Yes	Yes	Upgrade shell from 6 to 7 stars, retain solar PV as per BAU and meet the WoH requirements through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	Yes
6 stars	Yes	No	No	Upgrade shell from 6 to 7 stars and meet the WoH requirements (including for pool/spa pumps) through the lowest cost upgrade pathway	Yes, only for steel framed buildings	No
6 stars	Yes	Yes	No	Upgrade shell from 6 to 7 stars and meet the WoH requirements (including for pool/spa pumps) through the lowest cost upgrade pathway	Yes, only for steel framed buildings	Yes
6 stars	Yes	No	Yes	Upgrade shell from 6 to 7 stars, retain solar PV as per BAU and meet the WoH requirements (including for pool/spa pumps) through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	No
6 stars	Yes	Yes	Yes	Upgrade shell from 6 to 7 stars, retain solar PV as per BAU and meet the WoH requirements (including for pool/spa pumps)	Yes, only for steel framed buildings	Yes

Building characteristics in the BAU				Assumed upgrade pathway		
Baseline star rating	Pool/spa?	Difficult block?	Solar PV in baseline?	Upgrade pathway	Additional cost for thermal bridging mitigation?	Additional difficult block cost?
				through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)		
7 stars or above	No	No	No	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. WoH requirements are met through the lowest cost upgrade pathway	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only
7 stars or above	No	Yes	No	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. WoH requirements are met through the lowest cost upgrade pathway	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only
7 stars or above	No	No	Yes	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. Solar PV retained as per BAU. WoH requirements are met through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only
7 stars or above	No	Yes	Yes	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. Solar PV retained as per BAU. WoH requirements are met through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from

Building characteristics in the BAU				Assumed upgrade pathway		
Baseline star rating	Pool/spa?	Difficult block?	Solar PV in baseline?	Upgrade pathway	Additional cost for thermal bridging mitigation?	Additional difficult block cost?
						6 to 7 stars only
7 stars or above	Yes	No	No	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. WoH requirements (including for pool/spa pumps) are met through the lowest cost upgrade pathway	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only
7 stars or above	Yes	Yes	No	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. WoH requirements (including for pool/spa pumps) are met through the lowest cost upgrade pathway	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only
7 stars or above	Yes	No	Yes	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. Solar PV retained as per BAU. WoH requirements (including for pool/spa pumps) are met through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only
7 stars or above	Yes	Yes	Yes	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. Solar PV retained as per BAU. WoH requirements (including for pool/spa pumps) are met through the lowest cost upgrade pathway (this may involve adding more solar PV than under the BAU or changes to equipment selections under the BAU)	Yes, only for steel framed buildings	No – these costs are for dwellings being improved from 6 to 7 stars only

Building characteristics in the BAU				Assumed upgrade pathway		
Baseline star rating	Pool/spa?	Difficult block?	Solar PV in baseline?	Upgrade pathway	Additional cost for thermal bridging mitigation?	Additional difficult block cost?
CLASS 2						
6 stars	No - pools and spas in Class 2 dwellings are part of common areas	No	No - it has been assumed that Class 2 dwellings cannot install solar PV to offset SOUs' energy consumption	Upgrade shell from 6 to 7 stars and meet the WoH requirements through the 'all equipment upgrade pathway' (it has been assumed that Class 2 dwellings cannot install solar PV to offset SOUs' energy consumption)	Yes, only for steel framed buildings	Difficult block costs only apply to Class 1 dwelling
7 stars	No - pools and spas in Class 2 dwellings are part of common areas	No	No	Shell assumed to be equal to 7 stars (even if building has a higher star rating under BAU) so no additional improvements to shell. WoH requirements are met through the 'all equipment upgrade pathway' (it has been assumed that Class 2 dwellings cannot install solar PV to offset SOUs' energy consumption)	Yes, only for steel framed buildings	Difficult block costs only apply to Class 1 dwelling

Source: ACIL Allen

The specific equipment selections and solar PV capacity installed under each of the upgrade pathways described below (and the BAU) are outlined in more detail in EES' report '*NCC 2022 Update - Whole-of-Home Component'.*

Notably, while the lowest cost upgrade pathway has been assumed as the most likely response to the NCC 2022 for most Class 1 dwellings, consistent with the recommendations noted in the '*Report for Achieving Low Energy Homes'*, it is acknowledged that, in some cases, this may differ to the choices made for some dwellings. For instance, where a home has solar PV installed under the baseline, a marginal increase in solar capacity may maximise the benefits to the householder, but may not be the lowest cost option available.

In other cases, it has been argued that passive adjustments to design might be adopted. The RIS necessarily assumes design preferences are maintained (the exception is a reduction in window size assumed in TIC's thermal performance modelling, which is discussed further in Section 5.4.1). To assume otherwise would bring into question the revealed preferences under the status quo and overlook amenity costs.

Feedback provided during consultation shows that most stakeholders agree that industry will install what is the cheapest to meet the proposed new requirements (the cheaper of more efficient equipment or solar PV). Indeed, the majority of submissions (52 per cent) consider that it is reasonable to assume that industry's response to the proposed changes will be to select the lowest cost alternative in every case. This is in contrast to 10 per cent of submissions that consider this is not a reasonable assumption, 12 per cent that are unsure about this and the remainder of respondents (26 per cent) not answering the question.

In response to feedback received during consultation:

— The approach of selecting the lowest capital cost pathway to comply with the regulation has been maintained. This approach also acknowledges that the highest lifetime benefits are more likely to be reflected in the current proportion of buildings that over comply under the status quo.
— As noted in Section 5.3.1, for the Decision RIS, TIC and EES revised the optimisation of expected design solutions. The Decision RIS reflects this revised analysis, which has resulted in lower compliance costs and improved benefit-cost ratios. Additional details about the revised optimisation process by EES are provided in Box 5.1.

Box 5.1 Revised optimisation of expected design solutions

The technical modelling underpinning the impact analysis in the CRIS was based on a relatively simplistic approach to the assumed response to the regulation. This approach considered three main response options:

— retaining the BAU equipment selection and applying as much solar PV as is required to meet the requirements of Option A or B (up to a maximum of 10 kW) [125]

— altering the equipment selection only (i.e. not adding solar PV – this option is possible for all dwellings under Option B, but only in selected cases under Option A) [126]

— altering the equipment selection plus adding as much solar PV as is required to meet the particular regulatory stringency level. Under this option, it was assumed that in all cases heat pump space conditioning and heat pump water heating (+ solar PV as required) would be used as an alternative to the BAU equipment choices.

A review by EES of the application of this approach following the release of the CRIS revealed that the approach was overly simplistic and failed to deliver the most optimum results in terms of costs and benefits (particularly in the case of Class 2 dwellings). Furthermore, in the case of dwellings without heating or cooling this approach was generating a somewhat unlikely outcome where in many cases it was assumed that heating/cooling equipment would be installed as a means for compliance (thereby increasing both capital costs and increasing operational costs). In reality, minor improvements to the building shell performance or the water heater performance could achieve a compliant result at a far lower capital cost and without the added operational cost of a heater/cooler.

To solve these issues a new optimisation routine was developed for the DRIS modelling. This new optimiser allows for all practical solutions[127] within the modelled cases (77 combinations of heaters/coolers and water heaters combined with PV as/if required were modelled in each jurisdiction/climate zone) to be considered as potential compliance solutions for each case examined. Each optimisation is unique to each jurisdiction because fuel prices and feed-in tariffs (that vary from jurisdiction to jurisdiction) can be a significant determinant of what constitutes an optimal solution in terms of the societal cost metric.

The revised optimisation approach considers a much broader range of compliance options (which is considered to be more representative of the workings of the industry) and resulted in improved benefit/cost outcomes.

It should be noted that this revision to the analysis involves no changes to any of the underlying assumptions or calculations relating to energy savings achieved by the various upgrade options or to the assumed unit cost of building shell upgrades or equipment costs, as detailed in the CRIS documentation.

Improvements in benefit/cost outcomes are derived from a better optimised compliance pathway selection procedure. Whilst the new optimisation process is more nuanced and sophisticated than that used in the CRIS analysis, it is still working with a limited range of options and industry should be expected to achieve even better benefit/cost outcomes by drawing on an even broader and more nuanced range of compliance options available through the new NatHERS WoH tools.

Source: TIC 2022, *ABCB NCC 2022 – Energy Efficiency Provisions DRIS Update – Companion Technical Documentation*.

Assumed response to NCC 2022 by Class 1 dwellings

Class 1 dwellings built as **6 stars without solar PV** in the BAU and that have good solar access[128] are assumed to upgrade the building fabric to 7 stars and meet the WoH requirements using the lowest cost upgrade pathway of the alternative response options analysed by EES (outlined in Box 5.1).

Class 1 dwellings built as **6 stars with solar PV** under the BAU are assumed to upgrade the building fabric to 7 stars, retain solar PV as per the BAU and meet the WoH requirements through the lowest cost upgrade pathway of the alternative response options analysed by EES. In particular:

— If the dwelling meets or exceeds the NCC 2022 Performance Requirement with the equipment and solar PV selected in the BAU (plus an upgrade of the shell to 7 stars), then it is assumed that this combination is retained. Under this upgrade pathway, this dwelling will only face the additional costs and benefits associated with the upgrade of the building shell from 6 to 7 stars.

— If the equipment and solar PV selected in the BAU (plus an upgrade of the shell to 7 stars) do not meet the NCC 2022 Performance Requirement, then it is assumed that the dwelling meets the new requirements using the lowest cost upgrade pathway of the options modelled by EES. This may mean the addition of more solar PV than assumed under the BAU case or may involve changes to equipment selections.

Class 1 dwellings built as **7 stars without solar PV** under the BAU are assumed to not make any changes to the building shell (i.e. the shell is assumed to be kept at 7 stars) and meet the WoH requirement using the lowest cost upgrade pathway as discussed above.

Class 1 dwellings built as **7 stars with solar PV** under the BAU are assumed to not make any changes to the building shell (i.e. the shell is assumed to be kept at 7 stars) and meet the WoH requirements through the lowest cost upgrade pathway as discussed above.

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[125] If the lowest capital cost option required more than 7.5 kW of solar PV for a Class 1 dwelling then it was assumed that the next lowest cost option that required less than the noted solar PV capacity limits would be selected.

[126] Where equipment selection changes, there is a large number of combinations that could be used to meet the NCC 2022 requirements. EES only modelled an option where central conditioning systems/room conditioning systems are updated to a minimum 2.25 star rated (2019 zoned rating) reverse cycle ducted air-conditioner in combination with an average efficiency heat pump water heater.

[127] Naturally not every possible heater/cooler/hot water combination could be used in every case. For example, it was assumed that appliance service levels would not be reduced, that gas equipment could only be used in the compliance pathway if there was already a gas heater and or a gas water heater in the base case. Wood heating could only be used if it was already being used in the base case. In total there were about 17 such rules that needed to be applied in the optimisation process to help ensure an accurate reflection of expected industry/homeowner behaviour.

[128] Note that, as discussed in Section 5.3.5, the RIS assumes that all Class 1 dwellings can install solar PVs (i.e., have good solar access and no overshadowing issues).

Class 1 **detached dwellings built with a pool or spa** under the BAU, regardless of whether they are built at 6 or 7 stars and with or without solar PV are assumed to upgrade the building fabric to 7 stars and meet the WoH requirements using the lowest cost upgrade pathway of the alternative response options analysed by EES. Modelling of these dwellings by EES was very limited (these were modelled on the basis of a single representative equipment set up only[129]).

Assumed response to NCC 2022 by Class 2 dwellings

Class 2 dwellings built as **6 stars** under the BAU are assumed to upgrade the building fabric to 7 stars and meet the WoH requirements using an 'all equipment pathway' (which as discussed in Section 5.3.5, generally results in higher costs than using the lowest cost upgrade pathway of the alternative response options analysed by EES). While this is the most likely outcome given the practical difficulties with installing solar PVs in Class 2 dwellings (see Box 5.2 for a more detailed discussion about these issues), this may not always be the case (some Class 2 dwellings will install solar PV either because it is the lowest cost, or for other reasons).

Notably, this assumption was challenged by some stakeholders during consultation. The joint submission by PCA, ASBEC, GBCA and EEC and submissions by Renew and the New England Greens argue that a PV pathway should be considered for Class 2 buildings.

In their submission, PCA, ASBEC, GBCA and EEC suggest that anecdotal evidence from their members indicates that some do install solar PV to meet parts of the needs of common areas and individual units and note that, while there are some challenges associated with these dwellings, many solutions have been identified to overcome these problems. In their view, solar PV is achievable in a significant proportion of Class 2 dwellings and in many circumstances, this would be a lower cost pathway for compliance with the requirements than an equipment-only approach.

While we recognise the existence of new approaches to sharing solar benefits across individual units in Class 2 buildings that would address some of the challenges posed by these dwellings (for instance, Allume Energy's SolShare solution discussed in Box 5.2), it is considered that even with these innovative solutions, the problem of available roof area remains.

Overall, it is considered that exclusion of a PV pathway for high rise Class 2 dwellings appropriately reflects the likely response by industry given the costs of these solutions are likely to be higher than the current modelled approach in the majority of cases and the problem of available roof area.

Class 2 dwellings built as **7 stars** under the BAU are assumed to not make any changes to the building shell (i.e. the shell is assumed to be kept at 7 stars) and meet the WoH requirement using an 'all equipment pathway' as discussed above.

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[129] Additional details about the equipment in the pool scenario modelled can be found in EES's WoH report.

Box 5.2 Issues related to the installation of solar PV in Class 2 buildings

As noted above, for the modelling it has been assumed that all Class 2 dwellings meet the WoH requirements using an 'all equipment pathway' and that effectively solar PV cannot be installed to offset the energy of other regulated buildings elements in SOUs. This assumption has been made due to the current practical difficulties with installing solar PV on Class 2 buildings, which include the following.

— Roofs on Class 2 buildings are generally a shared resource managed by the body corporate (or owners corporation). The owners would require a special resolution to pass a new by-law for an individual unit of a Class 2 building to install solar PV for use solely in their dwelling.

— There are usually additional costs associated with the installation of solar PV on Class 2 buildings:
  - Class 2 roofs are often flat, which results in additional costs to ballast and tilt the solar panels to provide optimisation of the solar energy generated.
  - Tall buildings might require crane hire and traffic control from local council.
  - High wind loads atop tall buildings require additional fixings for the panels.
  - Cable runs between equipment components in Class 2 buildings tend to be longer and therefore more expensive compared to a Class 1 installation.
  - Under some configurations, or when using proprietary demand or generation management systems (such as the Allume SolShare device), an additional hardware and/or software cost would be imposed upon the system.

— Roofs in Class 2 buildings are commonly used for other purposes, including for plant and equipment, for building maintenance equipment or for other community activities like rooftop gardens, thereby potentially limiting the available space for solar PV installations.

Given the above, and as it is quite complex and costly to assign solar PV systems and their output to individual dwellings, the more common method of installing solar PVs on Class 2 buildings is for the body corporate to install the solar PV to offset the energy used in common areas and shared services (such as lifts and central hot water systems). In small-scale Class 2 buildings, the common area energy use may be very small (e.g. only the lighting of common areas) and substantially less than the daytime energy use of the individual dwellings. In these cases, the financial benefits of PV systems to households are significantly reduced because the solar feed-in tariffs are anywhere from 1/3 to ½ of the energy consumption tariff in most jurisdictions (except the NT).

New approaches to sharing solar benefits across SOUs in Class 2 buildings have been developed recently (for instance, Allume Energy's SolShare solution). However, these tend to be more expensive solutions that have only been deployed in a small number of situations.

Given the above, it is possible that any solar PV upgrade pathways to meet the proposed NCC 2022 requirements for Class 2 dwellings could result in higher costs than the 'all equipment pathway' selected for the analysis in this RIS.

Source: TIC 2020, Issues for Class 2 buildings and PV Installation - Proposed solution for the development of NCC 2022 regulations for Class 2; Solar Choice 2020, Solar for strata & apartment blocks: Everything you need to know (almost).

Assumed response to NCC 2022 by dwellings built with no heating, no cooling, or neither heating nor cooling

Some Class 1 and Class 2 dwellings are currently being built with no heating, no cooling, or neither heating nor cooling under the BAU. As indicated in Table 5.15, these dwellings represent a significant proportion of dwellings in some states (e.g. NSW, Queensland and WA). The proposed regulation will assume that a Minimum Energy Performance Standards (MEPS) level space conditioning heat pump is installed for the purposes of assessing compliance with the provisions (there will be no requirement to actually install this equipment). This is designed to ensure that heaters/coolers are not simply installed straight after occupancy as a means of avoiding that part of the compliance costs attributable to expected heating and or cooling societal costs. It also ensures that all dwellings are regulated on the basis of an assumed common level of service provision. This means that someone can choose to not put in heating or cooling but they are still required to make some provisions (in terms of offsets) in case heating and/or cooling is installed after occupancy. In light of this, EES included these dwellings in the modelling in the following way:

— In cases where solar PV can be installed, EES assumed that a MEPS level space conditioning heat pump would have been installed in the baseline and calculated the solar PV that would be required to comply with the regulation. Given the assumption of no shaded blocks discussed in Section 5.3.5, this is the solution/upgrade pathway that is assumed for all Class 1 dwellings with no heating, no cooling, or neither heating nor cooling under the BAU.

— In cases where solar PV cannot be installed, EES assumed that these buildings comply with the proposed NCC 2022 requirements by installing higher efficiency water heating equipment. This is a solution/upgrade pathway that is assumed for all Class 2 dwellings with no heating, no cooling, or neither heating nor cooling under the BAU. In reality, apartments with no heating/cooling can comply with the new requirements either through a higher performance building shell (above 7 stars) or a high efficiency water heater, or a combination of the two[130]. However, given the limitations on the extent of the modelling that EES conducted for the RIS, the option of using a higher performance building shell was not examined. In effect, the analysis assumes that the cost of complying via the high efficiency equipment upgrade pathway is roughly in line with the cost of complying via other alternative pathways. This assumption has not been validated.

[130] The regulation will also allow for PV to be installed; however, this is expected to be rare due to the practical difficulties identified in Box 5.2

Table 5.15 Proportion of Class 1 and Class 2 dwellings built with no heating or no cooling

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Class 1 dwellings								
No Heating	17.6%	1.0%	20.2%	5.0%	18.0%	0.5%	4.2%	0.5%
No Cooling	19.3%	3.7%	21.0%	9.7%	21.6%	8.1%	4.4%	3.1%
Class 2 dwellings								
No Heating	6.6%	1.1%	30.1%	8.0%	23.0%	1.0%	8.1%	1.0%
No Cooling	6.7%	1.1%	30.2%	9.2%	25.2%	2.0%	8.1%	2.3%

Note: Counterintuitively, the rate of no heating in jurisdictions such as the NT is apparently quite low. This is the case because in cooling dominated climates such as the NT, the use of air-conditioners (often with a reverse cycle option) is very high. So, whilst the installed equipment might have both heating and cooling modes, generally the occupant will only use the cooling mode.

Source: EES.

5.4 Dwelling compliance costs

This section describes some of the assumptions and inputs used to estimate the costs of the proposed changes to the NCC 2022 energy efficiency requirements.

5.4.1 Change in construction costs

The construction costs included in the RIS were estimated by EES and TIC by comparing the cost of complying with the minimum energy efficiency standards under the existing code (2019) and under the proposed minimum standards (2022). These estimates were based on market pricing information gathered from a range of sources.

To meet the proposed thermal requirements in NCC 2022 at the lowest cost of compliance, TIC's modelling of the impacts of the proposed changes:

1. Used cost-effective 7-star design optimisation techniques which included:
   – more nuanced use of high-performance glazing. For instance, using double-glazing with low coating and argon fill in rooms with the highest heating loads to maximise benefits. While low-e argon fill double glazing is more expensive, fewer windows need to be double glazed, therefore reducing the overall cost
   – selected trimming of window sizes (see below)
   – a more nuanced approach to the use of ceiling fans. For instance, using multiple large diameter fans in the largest room(s) with the highest cooling loads.
2. Assumed an average reduction in window size.[131] This change was based on CSIRO's dashboard data which shows that as rating levels increase, slightly smaller window sizes are selected. In particular, this data shows that the average window to floor area ratio in 7 star dwellings is lower than in 6 star dwellings. On average across Australia, 7 star dwellings have

[131] For further details about the assumed reductions in window sizes across different locations and climate zones, please refer to TIC's report '*Report 1: Cost and Benefits of upgrading building fabric from 6 to 7 stars*'.

around 15 per cent smaller windows as a proportion of floor area than 6 star dwellings. Reducing window area may be a response to contain overall glazing costs because a greater proportion of windows will need to be high performance in a 7star dwelling.

CSIRO's data reveals the observed design response of people who currently choose to exceed the minimum NCC requirements and build 7 star dwellings. While it is not clear that the design response to the proposed 7 star minimum regulatory requirements would be the same, TIC's modelling argues that it is reasonable to assume that a proportion of dwellings would respond to the regulations by reducing window size, so they assume that 60 per cent of the window area reduction observed in CSIRO's data is implemented to meet the new thermal requirements. Typically, the reduction in window area varied from 0 per cent to 8 per cent

Many submissions received during the consultation provided feedback with regards to how the CRIS estimates the different costs associated with the proposed requirements. Broadly, the key areas of feedback were around:

a) under/over estimation of costs, particularly in relation to the likely response of industry to the regulations
b) increased construction costs due to supply chain disruptions
c) the introduction of biases in the cost estimation through choices made on the technical modelling
d) differences between modelled and realised costs
e) the costs associated with difficult and shaded blocks
f) learning rates
g) industry costs.

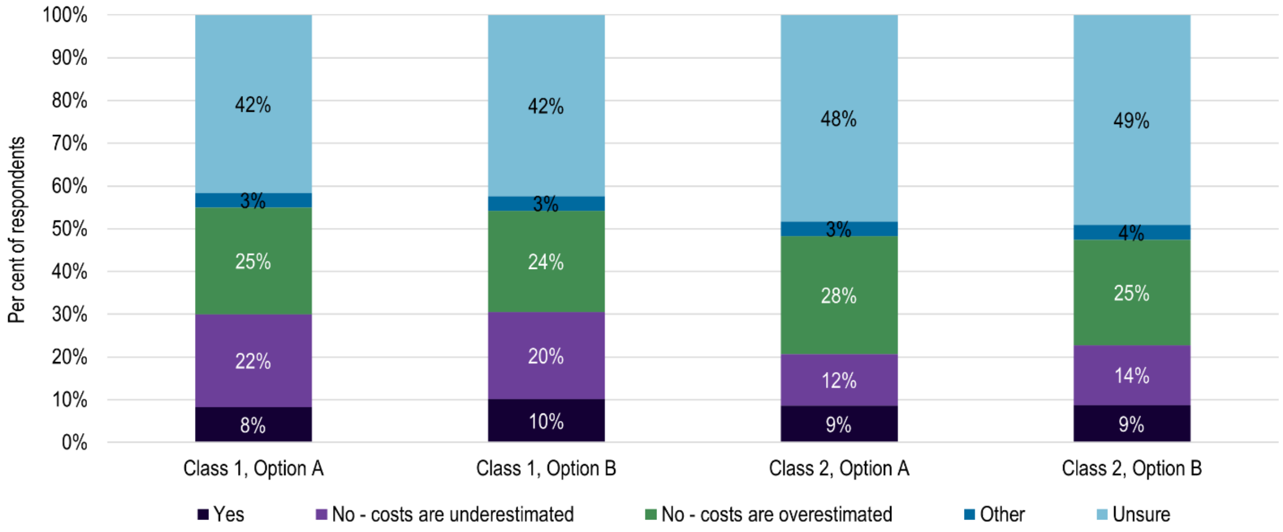
Issues a) to d) above are discussed in more detail in the sections below. Feedback associated with difficult and shaded blocks was discussed in Sections 5.3.4 and 5.3.5. Feedback around learning rates is addressed in Section 5.4.5 and about industry costs in Section 7.1.2.

Under/over estimation of costs

Submissions provided during consultation had different views with respect to whether the costs provided in the CRIS are reasonable, with some stakeholders arguing that the costs are overstated and others arguing that costs are understated. As shown in Figure 5.7:

— roughly the same proportion of stakeholders think that costs for Class 1 are underestimated (22 per cent for Option A and 20 per cent for Option B) and overestimated (25 per cent for Option A and 24 per cent for Option B), with slightly more people thinking the costs are overestimated
— a higher proportion of stakeholders think that the costs for Class 2 are overestimated (28 per cent for Option A and 25 per cent for Option B) than underestimated (12 per cent for Option A and 14 per cent for Option B).

Figure 5.7 Stakeholder views regarding whether the costs estimates presented in Chapter 5 of the CRIS are reasonable



Note: Responses refer to question 26, Are the cost estimates presented in this chapter reasonable? Chart excludes submissions that did not answer this question. Between 57 and 60 submissions answered this question.
Source: Citizen Space submission data.

Some submissions provided additional commentary around this issue. HIA disagrees with the use of wholesale construction costs in the economy-wide analysis in the CRIS. It argues that this assumption implies that '10 per cent of builders' capacity is idle'[132] and that, even if 'builders are not spending all of their time at work, this does not mean that 10 per cent of their time is free'[133]. HIA is of the view that 100 per cent of modelled construction costs should be included in the analysis. In this respect, it is important to note that the use of resource costs to value societal costs associated with construction is not to imply that '10 per cent of builders' capacity is idle'. Rather, that 10 per cent of the construction costs are fixed and would be incurred regardless of whether the proposed energy efficiency provisions in the NCC 2022 are adopted. These fixed costs relate to the overhead costs associated with operating businesses that support the construction industry. The remaining 90 per cent of costs are assumed to be variable which will or will not be incurred depending on the level of construction activity.

The HIA submission also argues that the costs of meeting the 7 star requirements are significantly underestimated in the CRIS, pointing to estimates provided by their members that suggest that cost increases would be between 2 per cent to 4 per cent, but that depending on the house design, orientation and owner preferences costs could increase between 5 per cent and 10 per cent. BlueScope Steel also supports the view that the costings in the CRIS are underestimated and suggests that fabric costs should be reviewed. Another submission noted that, while the previous increase in stringency from 5 to 6 stars was relatively easier to achieve at less cost, the proposed change from 6 to 7 stars is a 'step-change' that will not be easily achieved.

[132] HIA Submission (Letter), p. 37.

[133] Ibid.

In contrast to this view, the joint submission by PCA, ASBEC, GBCA and EEC and Renew's submission argue that the costs in the CRIS are overestimated. In particular, the joint submission suggests that the CRIS analysis does not reflect the most cost-effective solutions that are likely to be taken by industry, leading to unrealistically high incremental costs for the changes in thermal fabric. The joint submission also argues that higher building standards can be met by making 'basic' changes to the building design (e.g. changes in orientation, eaves and window sizing) and hence often achieved with little or even no marginal construction cost and sometimes there may even be construction cost reductions. Renew undertook their own modelling of the proposed NCC changes. A summary of how Renew's modelling differs to the modelling in the CRIS is provided in Appendix D.

Feedback provided during consultation highlights how differences in design can affect construction costs. Indeed, it can be argued that, to meet the 7 star shell requirements, industry could:

- retain the current rating practices and designs and meet the requirement through the use of more energy efficient materials (e.g. using more glazing) (an 'engineering' approach)
- use a more 'nuanced' approach to optimise designs like the optimisation techniques used by TIC in their modelling to meet the proposed thermal requirements at the lowest cost of compliance
- use a combination of the above.

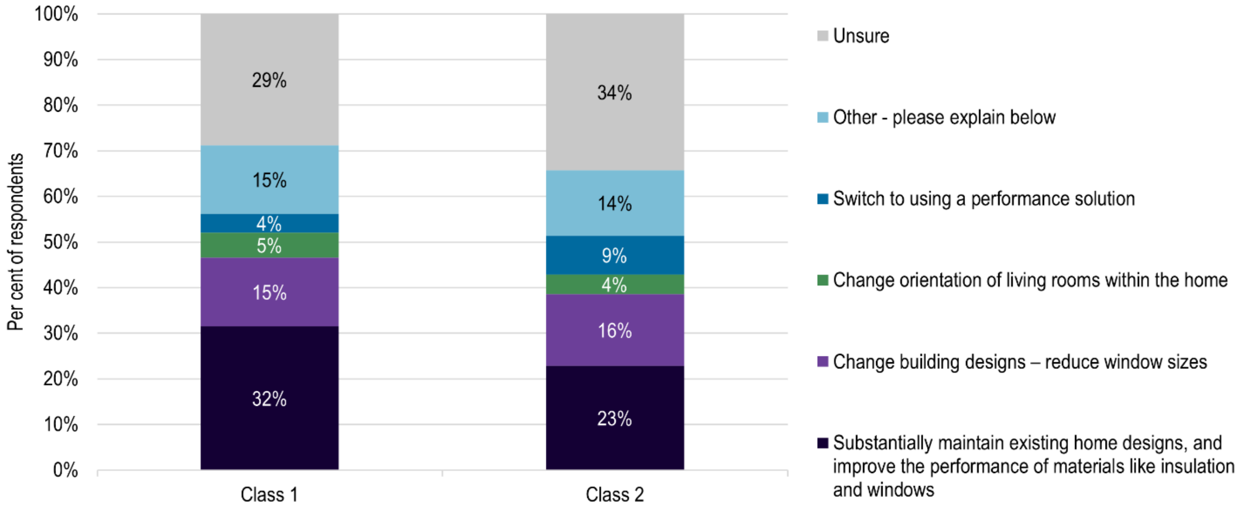
An engineering approach would result in higher capital costs, while the design optimisation approach would result in higher redesign costs (but overall lower capital costs).

Stakeholders provided good reasons for their arguments, and their differences reflect the complexity of the proposals being analysed and the sensitivity of some of the estimates to the range of assumptions used in the modelling. An area that received significant feedback with respect to their impact on the costs included in the CRIS is the changes in dwelling design in response to the policy initiative.

Some stakeholders argue that the costs in the CRIS are overestimated because compliance pathways in which dwelling design changes are made to lower the compliance costs are not included (e.g. a compliance pathway where changes are made to orientation, eaves and window sizes, or where certain features included in the baseline are not included in the policy case – for instance, a pool). Other stakeholders argue the contrary, suggesting that the dwelling sample used for the CRIS assumes optimal orientations and situations and hence underestimates the compliance costs.

An analysis of the submissions shows that the majority of stakeholders who provided an answer on this topic think that the most likely response from industry to the proposed thermal fabric changes in Class 1 dwellings would be to substantially maintain existing home designs and improve the performance of materials like insulation and windows. However, the majority of stakeholders were unsure about the likely response in Class 2 dwellings (see Figure 5.8).

Figure 5.8 Likely response by industry to the proposed thermal fabric changes



Note: Responses refer to question 14, How would industry most likely respond to the proposed thermal fabric changes under each of the proposed options? Chart excludes submissions that did not answer this question. Between 70 and 73 submissions answered this question.
Source: Citizen Space submission data.

Importantly, to provide additional clarity around the assumptions that were used in the CRIS with respect to changes in dwelling design in response to the proposed policy:

— Other than a reduction in window sizes and changes in roof colours (that reflect what the majority of homes do in some climate zones as shown in the CSIRO housing portal), modelling by TIC assumes that design preferences are maintained under the baseline and policy scenario (including dwelling size and orientation).

— The typical dwellings used by TIC in its modelling for the CRIS were deliberately sited on a non-optimal orientation with living areas facing south, east and west to account for a range of costs and benefits experienced by different sites.

The modelling in the RIS necessarily assumes design preferences are maintained (except in the limited circumstances noted above) as not doing so would bring into question the revealed preferences under the status quo and overlook amenity costs. By assuming similar archetypes, TIC's methodology focuses on measuring the real costs of the regulations under existing behaviour. It is considered that this method is appropriate as it recognises and avoids methodological issues in some previous reviews of energy efficiency interventions, where quantifiable costs are eliminated and/or treated as benefits (e.g. the cost of installing a more energy efficient pool pump is avoided by not building a pool, and the cost savings from not building a pool treated as benefits) while ignoring unquantifiable costs (e.g. the reduced amenity of not having a pool).

In response to the feedback provided during public consultation, TIC undertook a review of:

— modelling provided by six building companies' submissions using alternative approaches to improve the fabric energy rating from 6 to 7 stars to those used by the technical modelling underpinning the CRIS

— the impact on costs of maintaining window sizes.

After examination of the plans and costs provided by industry, TIC's analysis concluded that the differences in results were driven by several factors:[134]

— the house plans provided by industry are much larger than average. This increases the total cost, but the costs per square metre were still above those reported in the CRIS
— focussing (understandably) on the worst orientation, when the costs for more favourable window orientations is much lower
— a reliance on simple, but higher cost specification changes.

TIC noted that common approaches for 6-star design improvements are not the lowest cost strategy when used for 7-stars. 7-star requires a more nuanced approach to contain costs. The design optimisation techniques used in the RIS technical modelling significantly lower compliance costs, but will require more time to implement than across the board specification changes.

With regards to claims that the CRIS underestimated the costs of compliance in significant market segments because the houses assessed for the CRIS used dwellings with average window sizes and reduced window size to achieve 7-stars, TIC's analysis found the following.

— Not all houses will need to reduce window area, only poorly oriented dwellings like those modelled for the RIS.
— If window size is not reduced, the CSIRO's dashboard data shows that higher costs would only apply to 8.6 per cent of dwellings across Australia, and the net impact on costs would be small.
— Costs for dwellings with large window areas can be higher, but equally more easily avoided because these dwellings have more opportunity to reduce window area.

Furthermore, analysis conducted by TIC on the impacts on costs of maintaining the average 6-star window size at 7-stars in the houses modelled for the RIS showed that:

— Maintaining the same window size as used at 6-stars does result in higher costs than shown in the CRIS, but these costs are small.
— Savings are possible through better design, e.g. developing designs more suited to sites with problem orientation that do not have all living area windows concentrated in the worst orientation, flipping the house on the lot to improve window orientation and enhancing sales practices to ensure that dwelling designs are paired with lots with lower compliance costs.
— Competitive pressures may mean that significant segments of the industry will adopt window trimming for poorly oriented houses.

Overall, TIC's analysis concluded that the costs estimated for the building fabric upgrade under the central case in the CRIS remain robust and representative of average costs of the life of the regulation.

[134] Additional details about this analysis can be found in TIC's report '*A review of industry feedback and approaches to upgrading to 7-star building fabric*'.

Increased construction costs due to supply chain constraints

HIA's submission argues that the costs used in the CRIS were modelled prior to the substantial increases in building materials due to supply chain constraints and COVID-19, and that it is highly unlikely that the costs of material and labour will return to pre-COVID levels as suppliers are adding more domestic production to increase supply chain reliance. They suggest increasing the costs in the CRIS by 15 per cent to reflect these increases in input prices.

While the impact of COVID-19 on supply chains is acknowledged, it is important to note that:

— any increases in 'general' building materials would be experienced both under the base case and the policy case (i.e. even if the proposed amendments were not adopted, new buildings would experience these prices increases)

— no evidence was provided during consultation about COVID-19 induced price increases for the specific 'energy efficiency' building materials that would be needed to meet the proposed increased energy efficiency requirements (e.g. insulation and high performance glazing).

In light of the above, for completeness and to account for uncertainties in the compliance costs estimated (such as the supply chain disruptions noted by HIA), this DRIS includes additional sensitivity analysis showing the impact of increases in compliance costs on the NPV and BCR of the proposal.

Biases in the estimation of costs

Some submissions expressed concerns that some of the choices made in the technical modelling undertaken by TIC and EES have introduced biases in the estimation of the cost of compliance.

The joint submission by PCA, ASBEC, GBCA, EEC argues that the costs for Class 2 dwellings are overestimated as the modelling assumes that every Class 2 unit will need to meet a minimum of 7 stars, rather the current approach which requires Class 2 buildings to meet an average star rating and all units to be no more than one star below the minimum. While this is a valid concern, TIC's report[135] notes that this 'average + minimum' approach has been taken into consideration in their modelling. In particular, for the baseline, TIC's modelling combines 5-, 6- and 7-star rated apartments in a way that just complies with the minimum 5-, average 6-star NCC 2019 requirements and a similar process is done for the new stringency level of 6-stars minimum and 7-stars average (see page 16 of TIC's report). As such, the resulting marginal costs for an increase in the building fabric requirements represent an average of units at different star ratings.

PCA, ASBEC, GBCA, EEC also suggest that incremental hot water costs are assumed to be incurred in close to 100 per cent of the building class/climate zone combinations in Table 5.1 and Table 5.2 of the CRIS. We note that the costs included in these tables refer to 'composite' dwellings for climate zones/jurisdiction that account for the number of dwellings that would take each of the upgrade pathways described in Chapter 4 of the CRIS. In essence, these figures reflect a mix of dwellings,

[135] Tony Isaacs Consulting 2021, *Costs and Benefits of upgrading building fabric from 6 to 7 stars,* https://consultation.abcb.gov.au/engagement/consultation-ris-proposed-ncc-2022-residential/supporting_documents/Costs%20and%20Benefits%20of%20Upgrading%20Building%20Fabric%20from%206%20to%207%20Stars%20Tony%20Isaacs%20Consulting.pdf, accessed 8 December 2021.

some of which would have incremental hot water costs and some that would not. The cost tables in Appendix F show in more detail the hot water costs that would be incurred by individual dwellings taking different upgrade pathways. In these tables it is clear that not all dwellings would incur additional hot water costs. For instance, as shown in Table E.6, Class 1 dwellings currently built at 6 stars and with PVs installed under the baseline would not experience any hot water costs.

Another submission argues that the costs of upgrading to 7 stars are underestimated as the nine homes selected for the modelling are old in design and much smaller in area than the market currently is seeking and purchasing, which results in lower incremental costs to meet the proposed requirements, and higher benefits due to NatHERS' area adjustment factors and reduced glazing areas. HIA also argues that the sample houses used for the 7 stars case studies are not representative examples of homes and apartments built, or they have chosen to have optimal orientations and situations, resulting in costs that are not reflective of real world situations.

In contrast with these views, AGWA suggests that reductions in the overall floor area of dwellings should be modelled to reflect CSIRO's housing data indicating reductions in dwelling size associated with star rating increases (19 per cent decrease in dwelling sizes on average when ratings are increased from 6 to 7 stars) and achieve substantial upfront cost savings.

With regards to the concerns raised about the building sample used to model the costs and benefits of the new proposed requirements it is important to note the following:

— the plans and rating files used by TIC's analysis are sourced from NatHERS. This was done so that the dwellings modelled represent the current market response to achieving compliance and reflect the most common/typical characteristics of the dwellings currently being built
— as noted by TIC (p. 12), 'While the dwellings used may not look like the latest houses on offer from builders, in terms of modelling energy savings and upgrade costs it is not the appearance that matters, but the set of geometric and thermal properties of the dwelling that affect the accuracy of these predictions'. In this respect, the designs selected for the modelling are representative because these properties have been corelated with the industry response at 6-stars as shown in the CSIRO housing portal
— the age of design does not necessarily affect the costs of upgrade. In fact, more modern designs may be better adapted to the regulatory energy efficiency process and be cheaper to upgrade
— as discussed before, the dwellings used by TIC in their modelling do not have optimal orientation. In most climates, optimal orientation entails orientation of living areas to the north. In the dwellings modelled by TIC, the front door faces north and the majority of living areas face the backyard or side of the house. Hence, the dwelling sample is not biased toward least cost solutions. Furthermore, while TIC's modelling evaluated passive solar or well ventilated dwellings, as noted before, their upgrade costs were excluded from the impact analysis in the CRIS (these dwellings were used to demonstrate the savings potential of more climate appropriate designs)
— one way in which TIC did seek to minimise compliance costs was to concentrate higher performance glazing in the rooms with the highest energy loads, and to use the highest practical glazing performance(e.g. lowest Solar Heat Gain Co-efficient (SHGC) in hot climates, low emissivity (low-e) coated argon filled double glazing in cool climates).These are options that are available to industry to lower the compliance costs associated with the proposed requirements.

Differences between modelled and realised costs

HIA argues that modelled cost increases significantly underestimate the actual costs increases experienced by industry, and as such, the costs in the CRIS should be adjusted to reflect actual/realised costs. HIA cites a 2005 report by the Productivity Commission (PC) that suggested that:

> evidence is now appearing of compliance costs [for building energy efficiency standard] being much higher than expected. For example, the Victorian Government predicted the cost of a new house would rise by 0.7 – 1.9 per cent, but a recent survey shows that the average increase was 6 per cent[136]

Based on the PC report, HIA suggests that, at a minimum, modelled costs should be increased by a factor of three to account for these discrepancies (6 per cent vs 1.9 per cent).

Other research undertaken after the 2005 PC report suggests the opposite – that actual compliance costs are lower than modelled costs.

— In a 2008 study of the actual costs of 5-star houses in Victoria, ACIL Tasman[137] found that the typical cost of improving the building envelope to 5 stars was $2,064. This is 37 per cent lower than the average cost predicted by the benefit-cost evaluation undertaken for the 5 star regulations in Victoria.

— A 2019 evaluation of the Victorian 6 star housing standard[138] examined cost data from the original 2009 6 star RIS and commissioned specialist firm Evissa Pty Ltd to quantify current incremental costs. This evaluation notes that incremental construction costs appear to have fallen by 2.4 per cent per year for houses and 13 per cent per year for apartments, but may have risen for townhouses by 8.6 per cent per year. However, SPR notes that they have lower confidence in the townhouse results as the townhouse designs modelled in the two time periods are different. Indeed, they note that, had the 2009 and 2018 townhouse costings been made on a comparable basis, or more data points available, they would expect a similar cost reduction over time as for houses, primarily because high-performance glazing costs have fallen over time.

— A study by Sustainable Built Environment (SBE) for the Victorian Building Commission[139] that reviewed the regulatory impact of the 5 Star Standard for Class 1 buildings in Victoria in 2004 (immediately prior to the introduction of the 5 Star Standard) and 2008 (three years on), explains that house designs were being adapted to use lower-cost techniques. These lower-cost techniques included waffle pod slabs, increased use of concrete slab floors in general, lower window areas, and improved aluminium window frames.

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[136] Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, https://www.pc.gov.au/inquiries/completed/energy-efficiency/report/energy.pdf, pg. XXXVII.

[137] ACIL Tasman 2008, *Evaluation of the Victorian 5 Star Building Standard*, report prepared for the Victorian Department of Sustainability and the Environment, Melbourne.

[138] Strategy. Policy. Research. 2019, *Evaluation of the Victorian 6 Star Housing Standards – Final Report*, prepared for the Department of Environment, Land, Water and Planning, July.

[139] Sustainable Built Environment (SBE) 2010, *Benchmarking study of residential building performance*, prepared for the Building Commission and Sustainability Victoria, Melbourne.

- CSIRO's evaluation of the 5 star energy efficiency standard for residential buildings[140] found that houses with higher star ratings were cheaper to build than houses with lower star ratings, based on a review of hundreds of houses in Brisbane, Melbourne and Adelaide. The key cost savings came from more compact building forms, with lower external surface areas and smaller windows.

In response to the feedback received and to account for the complexities and uncertainties in the compliance costs modelled, this DRIS includes additional sensitivity analysis showing the impact of increases in compliance costs on the NPV and BCR of the proposal.

Way forward for the costs estimated in the DRIS

The following points summarise the approach taken with regards to the estimation of costs in the DRIS in response to the feedback received during consultation. This approach is based on the analysis in the sections above and discussions with the ABCB, EES and TIC.

- As discussed in Box 5.1 in Section 5.3.6, in response to feedback from consultation, a more nuanced and sophisticated optimisation process of expected design solutions to meet the WoH requirements was developed by the ABCB's technical consultants. This revised process results in lower compliance costs than those in the CRIS. Notably, these changes in costs are a result of the revised optimisation approach which considers a much broader range of compliance options that are more representative of the likely industry responses to the regulation — no changes were made to the assumed unit cost of building shell upgrades or equipment costs. The unit costs of building shell upgrades and equipment cost remain as described in the CRIS documentation[141].
- It is acknowledged that, while TIC's estimated costs and benefits for the building fabric upgrade appropriately represents the impacts of the requirements on the *average* homes currently being built, the approach might not appropriately reflect the costs of a *marginal* home which has specific characteristics (e.g. larger floor areas, inflexible design due to consumer preferences, small/narrow blocks, etc.) that may result in increased/decreased costs/benefits. While the costs estimated for the building fabric upgrade under the central case remain unchanged from the CRIS, in response to the feedback received during consultation, Section 6.1.1 in this DRIS incorporates two case studies showing the impacts on costs of alternative design choices (one for a dwelling with large floor areas and large windows, and one for a passively designed house).
- Reflecting the feedback received, the technical analysis underpinning the DRIS continues to assume that:
  - industry's response to the proposed changes will be to select the lowest cost pathway to achieve compliance as discussed in Section 5.3.6
  - the most likely response of industry to the proposed thermal fabric changes would be to substantially maintain existing home sizes and designs (the exception being the reduction in window size assumed in TIC's thermal performance modelling).

[140] Ambrose MD, James M, Law A, Osman P & White S 2013, *The evaluation of the 5-star energy efficiency standard for residential buildings*, CSIRO, Canberra.

[141] More information on these costs is provided in EES's and TIC's reports, *NCC 2022 Update - Whole of Home Component (May 2021) and Cost and Benefits of upgrading building fabric from 6 to 7 stars* (September 2020).

- the resource cost of these changes in construction is equal to 90 per cent of the construction costs estimated by EES and TIC.[142] Resource cost is the opportunity cost of allocating resources to the production and installation of the energy efficiency upgrades (instead of some other products or services). In calculating opportunity costs, producer surplus and costs of labour that would otherwise be unemployed are deducted from gross costs. Producer surplus is the difference between what producers are willing and able to supply a good for and the price they actually receive.

— For completeness, and to account for the complexities and uncertainties in the compliance costs modelled, the DRIS includes additional sensitivity analysis showing the impact of increases in compliance costs on the NPV and BCR of the proposed regulation.

The estimated changes in construction costs for Class 1 and Class 2 buildings under the different upgrade pathways described in Section 5.3.6 are outlined in the next chapter.

5.4.2 Equipment savings

Improving the thermal performance of new dwellings from 6 to 7 stars could have implications for the choice of space conditioning equipment. Air-conditioning and heating equipment need to be of sufficient capacity to ensure that comfortable temperatures can be maintained within the dwelling under most climatic conditions.[143] As thermal performance improves, the dependence on these equipment to provide comfort decreases and smaller equipment can be installed to provide the same level of comfort.

Savings from potential reductions in the capital cost of space conditioning equipment due to an improved thermal shell resulting from the proposed NCC changes (i.e. due to smaller equipment being installed as a result of moving from 6 to 7 stars) were estimated by EES for the NCC 2022 RIS process. The average equipment cost savings per dwelling as estimated by EES for each jurisdiction are outlined in Table 5.16.

These equipment savings are applied as a cost offset to the construction costs for all dwellings that are built as 6 stars under the BAU (i.e. dwellings that are already 7 stars under the BAU do not receive this savings).

[142] The resource cost of different types of construction products varies as there are a number of margins applied throughout the supply chain (e.g. wholesaler and retailer margin and transport margins). A 10 per cent discount on retail costs has been used to approximate the resource cost of construction products based on research by the Reserve Bank of Australia (RBA) that showed that 'the cost of goods accounts for around half of the final sale price of retail items, shared between its two inputs – imports and domestically produced goods... The remainder reflects the cost of distribution. Splitting this into the various inputs involved in distribution shows that around 20 per cent of the final price is attributable to each of labour and intermediate inputs used by distributors, with the final 10 per cent of the sale price being the net profit of wholesalers and retailers combined'. D'Arcy, P., Norman, D. and Shan, S. 2012, *Costs and Margins in the Retail Supply Chain,* RBA Bulletin June Quarter 2012, https://www.rba.gov.au/publications/bulletin/2012/jun/2.html.

[143] ABCB 2006, *Regulation Impact Statement: Proposal to amend the Building Code of Australia to increase the energy efficiency requirements for houses*, March.

Table 5.16 Average equipment cost savings per dwelling by jurisdiction

Jurisdiction	Class 1 ($ per dwelling)	Class 2 ($ per SOU)
NSW	$145	$151
QLD	$142	$112
VIC	$364	$175
SA	$232	$159
WA	$166	$123
TAS	$211	$158
NT	$141	$143
ACT	$236	$171

Note: In Class 2 dwellings there may be further savings available. The cumulative savings for all dwellings may reduce the capital cost of energy supply infrastructure for the whole building. This energy supply infrastructure benefit for the whole apartment building has not been estimated or included in the analysis

Source: EES.

Importantly, while these equipment savings were included in the CBA, EES noted that these benefits may not be achieved in practice due to a number of issues, including the following:

- Delivering these benefits would require the industry to change practices. A 7-star version of a dwelling would have lower peak loads than a 6-star version of the same dwelling. Theoretically, this should lead to the installation of a smaller sized equipment. However, delivering this cost saving would require the industry's equipment sizing practices to reflect the dwelling's energy efficiency. While the Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH) has produced some useful equipment sizing applications, these are not in general use. Until industry equipment sizing practices change (and more accurate equipment sizing guidelines using NatHERS outputs are developed), this will remain a potential benefit rather than an immediately deliverable benefit.
- Heating and cooling equipment only comes in incremental sizes. If equipment size increments are too broad, then even allowing for the reduced building load due to improved thermal fabric and higher requirement for equipment efficiency, the next smaller equipment may be too small.

5.4.3 Difficult blocks costs

Section 5.3.4 outlined the issues associated with difficult blocks and the estimated proportion of residential lots that fall within the small and narrow lot categories in each jurisdiction. The additional costs of compliance associated with these blocks that were included in the modelling are summarised in Table 5.17. [144] As noted before, these additional costs are only incurred by Class 1 dwellings that are currently built at 6 stars under the BAU. These costs do not apply to Class 2 dwellings or any Class 1 dwellings built at 7 stars or above under the BAU.

Table 5.17 Additional construction costs to improve from a 6-star to a 7-star dwelling on a difficult block (compared to improving from a 6-star to a 7-star on a 'standard' non-difficult block), $2021

NCC Climate zone	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Detached houses								
1 - High humidity summer, warm winter	NA	NA	25,900	NA	26,700	NA	27,500	NA
2 - Warm humid summer, mild winter	0	NA	4,800	NA	NA	NA	NA	NA
3 - Hot dry summer, warm winter	NA	NA	4,800	NA	0	NA	0	NA
4 - Hot dry summer, cool winter	2,200	9,500	NA	0	2,700	NA	NA	NA
5 - Warm temperate	2,200	NA	4,800	5,700	2,700	NA	NA	NA
6 - Mild temperate	1,800	9,500	NA	5,700	13,000	NA	NA	NA
7 - Cool temperate	9,000	15,600	NA	NA	NA	8,100	NA	9,000
8 - Alpine	0	0	NA	NA	NA	NA	NA	NA
Attached houses								
1 - High humidity summer, warm winter	NA	NA	2,100	NA	0	NA	2,100	NA
2 - Warm humid summer, mild winter	0	NA	**-400**	NA	NA	NA	NA	NA
3 - Hot dry summer, warm winter	NA	NA	**-400**	NA	0	NA	0	NA
4 - Hot dry summer, cool winter	0	0	NA	0	**-150**	NA	NA	NA
5 - Warm temperate	2,500	NA	**-400**	2,500	**-150**	NA	NA	NA
6 - Mild temperate	2,500	9,000	NA	2,500	5,200	NA	NA	NA

[144] Importantly, AECOM did not provide estimates for all dwellings across all locations for all of the types of difficult blocks. Any data gaps in this analysis were filled with assumptions provided by the ABCB.

NCC Climate zone	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
7 - Cool temperate	9,000	9,000	NA	NA	NA	9,000	NA	9,000
8 - Alpine	0	0	NA	NA	NA	NA	NA	NA

Note: AECOM did not provide estimates for all dwellings across all locations for all of the types of difficult blocks. Any data gaps in this analysis were filled with assumptions provided by the ABCB. Negative numbers imply a cost saving. NA= Not applicable.

Source: ABCB and AECOM 2020, Difficult Blocks – Final Report Revision 2, September.

5.4.4 Thermal bridging costs

As noted in Section 5.3.3, the CBA accounts for the costs of thermal bridging mitigation measures for steel frame buildings that are proposed in the NCC 2022. These costs, and the impact of the thermal bridging on the heating and cooling loads[145], have been estimated by TIC[146] and are presented in Table 5.18 and Table 5.19.

Table 5.18 Impact of steel frame thermal bridging at 6-stars in various climates, Class 1 dwellings

NatHERS Climate zone	Location	Added Cooling (%)	Added Heating (%)	Average additional cost of thermal bridging mitigation per dwelling
1	Darwin	2.5%	0.0%	$1,060
32	Cairns	0.9%	0.0%	$939
10	Brisbane	1.1%	32.0%	$1,514
3	Longreach	1.9%	9.6%	$875
27	Mildura	4.6%	18.8%	$1,682
28	Western Sydney	3.3%	22.3%	$1,669
13	Perth	2.7%	9.9%	$879
16	Adelaide	9.1%	27.4%	$1,747
60	Melbourne	1.3%	26.5%	$1,670
26	Hobart	-15.7%	20.5%	$1,681
24	Canberra	-5.3%	25.1%	$1,689
69	Thredbo	10.7%	30.6%	$1,680

Source: Energy Efficiency Strategies (EES) 2021, NCC 2022 Update - Whole-of-Home Component, Draft Report, May.

145 As noted in Section 5.3.3, the changes in energy consumption from thermal mitigation measures are not incorporated in the CBA as these have already been accounted for in a previous RIS.

146 For additional details of how these impacts were calculated please refer to TIC's report *Evaluating the impact of thermal bridging on energy savings predicted for the NCC 2022 RIS*.

Table 5.19 Impact of steel frame thermal bridging at 6-stars in various climates, Class 2 SOU dwellings

NatHERS Climate zone	Location	Added Cooling (%)	Added Heating (%)	Average additional cost of thermal bridging mitigation per dwelling
1	Darwin	0.4%	0.0%	$141
3	Longreach	0.9%	4.7%	$118
10	Brisbane	0.6%	8.0%	$99
13	Perth	0.5%	0.7%	$133
16	Adelaide	0.9%	4.2%	$156
21	Melbourne	0.9%	2.0%	$126
24	Canberra	0.9%	2.2%	$160
26	Hobart	-1.2%	3.5%	$110
27	Mildura	0.9%	3.1%	$137
32	Cairns	0.6%	0.0%	$130
56	Sydney	0.6%	5.6%	$160

Source: Energy Efficiency Strategies (EES) 2021, NCC 2022 Update - Whole-of-Home Component, Draft Report, May.

These costs are applied to steel framed buildings. The proportion of steel framed residential buildings in each jurisdiction are outlined in Table 5.20 and Table 5.21.

Table 5.20 Percentage of detached houses (Class 1) by structural framing, 2018

Jurisdiction	Timber	Lightweight steel	Double brick	Structural insulated panels
NSW	82%	14%	2%	2%
VIC	82%	11%	5%	3%
QLD	81%	18%	1%	0%
SA	85%	13%	2%	0%
WA	10%	12%	76%	2%
TAS	96%	0%	2%	2%
NT	8%	85%	0%	8%
ACT	100%	0%	0%	0%
Total	74%	13%	11%	2%
Market size adjusted [a]	73%	14%	11%	2%

[a] To account for varying sample coverage in each state, survey responses for each state are weighted to reflect the state's actual market share.

Source: Australian Construction Insights (ACI) 2018, Framing material use in residential construction, an investigation of the factors influencing framing material choice in residential building: 2018 follow up, September.

Table 5.21 Percentage of Class 2 (3 or less storeys) by structural framing, 2018

	Timber	Lightweight steel	Double brick	Structural insulated panels	Concrete
NSW	83%	4%	5%	2%	7%
VIC	31%	2%	6%	3%	58%
QLD	30%	1%	59%	2%	7%
SA [a]	46%	7%	21%	5%	22%
WA	3%	35%	42%	19%	1%
TAS	67%	0%	16%	16%	0%
NT [a]	46%	7%	21%	5%	22%
ACT [a]	46%	7%	21%	5%	22%
Total	23%	24%	39%	15%	16%
Market size adjusted [a]	46%	7%	21%	5%	22%

[a] The original ACI report did not have any data for SA. NT or ACT. ACIL Allen assumed that these states have the same proportion of steel (and other materials) framed buildings as the market adjusted total.
[b] To account for varying sample coverage in each state, survey responses for each state are weighted to reflect the state's actual market share.
Source: Australian Construction insights (ACI) 2018, Framing material use in residential construction, an investigation of the factors influencing framing material choice in residential building: 2018 follow up, September.

5.4.5 Learning rates

Learning effects (or learning rates) refer to the rate at which the cost of energy efficiency measures fall over time as a function of:

— industry learning (e.g. building designers can retrofit buildings to achieve a higher energy efficiency standard at a lower cost)

— costs of building materials and energy efficiency products reducing over time as the increased demand leads to economies of scale in production and technological innovation

— labour costs reducing over time as builders become more experienced with applying new building materials, equipment and techniques that may be required to achieve higher energy efficiency.

There are a few studies that discuss learning rates:

— A study by the Moreland Energy Foundation into how the residential buildings sector has responded to the introduction of the 6 star energy efficiency standard found an annual industry learning rate of 7.5 per cent over the 2014-2017 period (7.1 per cent for Class 1 dwellings and 1.7 per cent for Class 2 dwellings). However, it is noted that this is based on a very limited sample and is not statistically significant.[147]

[147] Moreland Energy Foundation 2017, *Changes Associated with Efficient Dwellings Project – Final Report*, prepared for the Department of the Environment and Energy.

— An evaluation of the Victorian 6 Star Housing Standard for the Department of Environment, Land, Water & Planning highlights the following estimates for lighting equipment:

  – LEDs are estimated to have experienced a learning rate of 28 per cent per year around the middle part of this decade

  – the International Energy Agency notes compact fluorescent lamps as having experienced a 10 per cent learning rate earlier this decade (other sources note higher values in earlier time periods – noting that this technology first emerged in the 1970s).[148]

— A report by HoustonKemp advising on the methodology to be used for residential building RISs recommends the following:

  ….a cost efficiency rate of 2 per cent year-on-year as a starting point with sensitivities of 1 per cent (lower bound) and 3 per cent (upper bound). These rates are broadly consistent with what is considered in other sectors, e.g., the electricity and gas network sector. [149]

— A 2017 study for the Department of the Environment and Energy reviewed the evidence on learning rates and found that, on average, the prices of energy-related building products had declined only modestly in real terms over the period from 2004 to 2016.[150] Specifically, the real price of a basket of energy-related building products:

  – declined by 0.4 per cent in unweighted terms

  – declined by 0.2 per cent in weighted terms. [151]

— The Low Carbon Living Co-operative Research Centre technical report on building code energy performance which outlines the modelling done for ASBEC's *Built to Perform – An industry led pathway to a zero carbon ready building code* and models the impacts of increased energy efficiency standards for new buildings did not apply learning rates to the prices of building elements used in their modelling. The rationale for doing so was that "while intuitively it is relatively straightforward to posit the existence of learning rates, and to build these into the regulatory benefit-cost analysis, finding hard evidence with which to quantify rates is extremely problematic".[152]

— The 2018 RIS on the inclusion of heating and cooling energy load limits in NatHERS assessments did not apply a learning rate or change in real costs over time (primarily because most scenarios involved net construction cost savings but also because of the minor nature of the changes involved).[153]

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[148] Strategy. Policy. Research (SPR) 2019, *Evaluation of the Victorian 6-star Housing Standard - Final Report*, prepared for the Department of Environment, Land, Water & Planning, July.

[149] HoustonKemp 2017, Residential Buildings Regulatory Impact Statement Methodology, report for the Department of the Environment and Energy, April, p.22.

[150] Strategy. Policy. Research.2017, Quantifying Commercial Building Learning Rates in Australia: Final Report, Prepared for the Department of the Environment and Energy, June 2017, p. v.

[151] The basket included over 150 energy-related building elements, including insulation products, glazing, and different kinds of mechanical and electrical plant, including lighting, which were priced by quantity surveyors, Donald Cant Watts Corke.

[152] Bannister, P., Robinson, D., Reedman, L., Harrington, P., Moffitt, S., Zhang, H., Johnston, D., Shen, D., Cooper, P., Ma, Z., Ledo, L., The Green, L. 2018, *Building Code Energy Performance Trajectory – Final Technical Report*.

[153] Strategy. Policy. Research (SPR) 2018, *Inclusion of heating and cooling energy load limits in NatHERS assessments, Regulation Impact Statement for decision*, prepared for the Australian Building Codes Board.

- The 2018 Decision RIS for energy efficiency of commercial buildings in the NCC 2019[154] did not include learning rates in the central case analysis as they concluded that there was not enough evidence to support a general learning rate *linked to regulatory change.* The RIS also noted that:

  > in some circumstances, buildings constructed under the baseline scenario (i.e. constructed under existing NCC minimum requirements) would also benefit from declining prices of building products. Where the price declines for inputs that are used under both the baseline scenario and where stricter minimum performance requirements apply, there would be no change in the incremental cost of achieving higher standards. Even where the price of inputs used to achieve higher standards (but not necessarily under the baseline) falls, lower prices may encourage greater uptake of these products under the baseline. For example, declining prices has encouraged greater uptake of LED lighting even without the need for regulation.

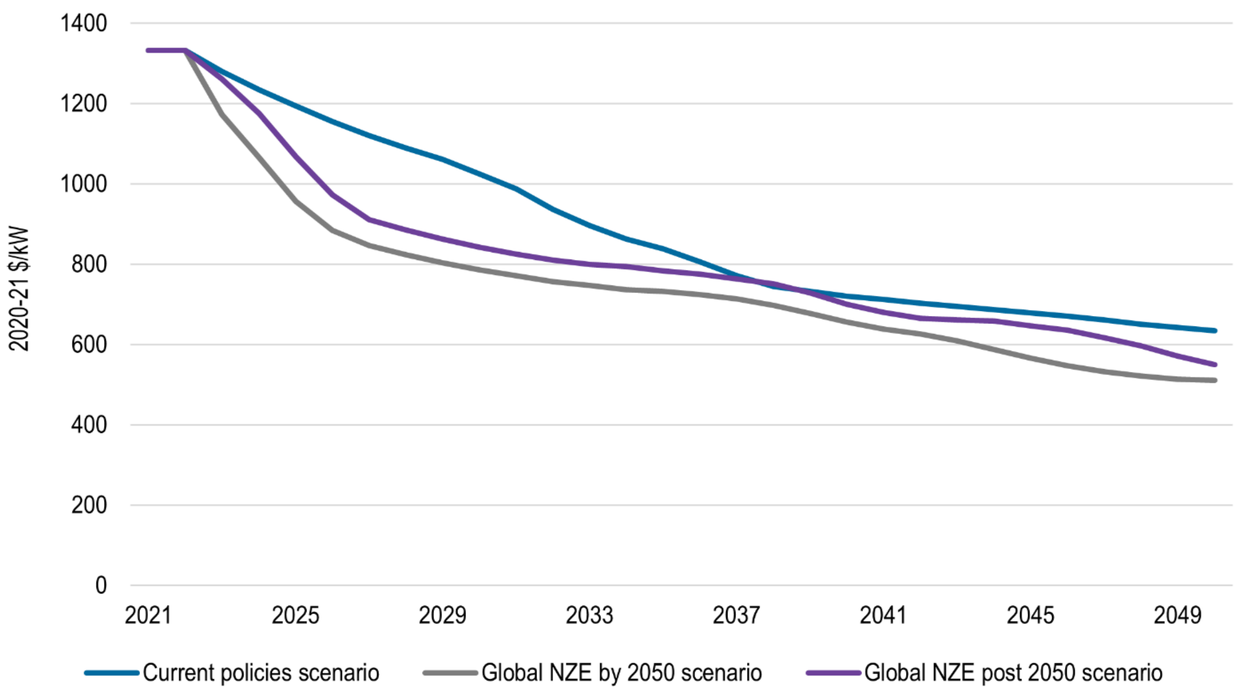
  And that:

  > Where cheaper and more energy efficient technologies (and there are no compromises on other characteristics) becomes available (such as LED lighting), they are likely to be adopted by industry even without the need for regulatory change.

- Each year CSIRO and the Australian Energy Market Operator (AEMO) produce a report on electricity generation and storage costs with a strong emphasis on stakeholder engagement (the GenCost report). This report includes past data and projections on the capital costs of rooftop solar PV. The GenCost 2021-22 report shows a clear trend of decreasing capital costs for solar systems across the three scenarios modelled (see Figure 5.9) that extends for at least two decades.

[154] Centre for International Economics (CIE) 2018, *Decision Regulation Impact Statement, Energy Efficiency of Commercial Buildings*, prepared for the Australian Building Codes Board, 13 November.

Figure 5.9 Projected capital costs for rooftop solar PV by scenario



Note: The current policies scenario refers to current stated global climate polices, with the most likely assumptions for all other factors such as renewable resource constraints. The Global NZE by 2050 scenario refers to a world that is driving towards net zero emissions by 2050 together with high levels of electrification and hydrogen consumption and trade. The Global NZE post 2050 scenario refers to a world where most developed countries are striving for net zero emissions by 2050 but others are lagging such that global net zero emissions are reached by 2070.

Source: Graham, P., Hayward, J., Foster J. and Havas, L, 2021, GenCost 2021-22: Consultation Draft, Australia, December.

In light of the evidence provided above, the central case analysis in this CRIS:

— included the CSIRO's projected reductions in costs (learning rates) of rooftop solar PV
— did not included learning rates for any other upgrade costs.

Several submissions provided during consultation commented on the assumptions about learning rates used in the CRIS analysis. The joint submission by PCA, ASBEC, GBCA and EEC and submissions by Renew, the New England Greens and another submission argue that assuming zero learning rates for all costs (other than PV costs) is unreasonable and that the RIS should factor expected technological improvements which would bring down the costs of equipment, materials and practices. The joint submission suggests using HoustonKemp's recommendation to apply a learning rate of 2 per cent year-on-year[155].

[155] HoustonKemp 2017, Residential Buildings Regulatory Impact Statement Methodology, report for the Department of the Environment and Energy, April, p.22.

AGWA argues that industry experts and key stakeholders they surveyed predict sizable downward pressure on costs for Insulated Glass Units (IGUs) and high-performance glazing systems as a result of increased economies of scale and greater market penetration driven by regulatory reform and increased energy efficiency stringency in the NCC. They refer to estimates provided by industry that indicate that a minimum 5-10 per cent reduction in manufacturing costs has been achieved over the last 5 years in markets with greater penetration of higher performing glazing systems and similar gains are predicted as a result of the proposed increase from 6 to 7 stars. AGWA also notes that further research is necessary to better understand and quantify these learning effects in the local market and asks that consideration is given to trends observed internationally to support these findings.

In contrast, HIA argues that learning rates for PVs should be removed from the analysis, or, if kept in the analysis the benefits related to their installation should fall too (because these cost reductions will cause more people to install PV regardless of the regulation and hence there is less scope for the new regulations to cause people to change their decisions). In this respect, we note that an increase in PV penetration is accounted for in the baseline in the CRIS, and so a reduction of PV benefits as a result of the regulation is already included in the modelling.

Learning rates can have a significant impact on the results of the impact analysis. For example, applying a reduction of 2 per cent year-on-year as suggested by HoustonKemp would result in costs in year 10 of the regulation being 16.6 per cent lower than in year one, which would be quite a significant decrease, especially for non-innovative products/materials offered by mature, competitive industries.

The price of new technologies and energy efficiency inputs can often decline rapidly initially before levelling off as the rate of learning slows. For instance, LEDinside's[156] tracking of street prices of LED bulbs shows that the average price of 60-watt equivalent LED products had dropped from around US$45-50 in January 2011 to below US$10 by July 2018, with the current price for LED lamp products today being one fifth compared to the price seven years ago[157]. However, as shown in Figure 5.10, the prices for LED lighting have started to level off, so it is unlikely that prices for this technology would reduce much further in the future. Similarly, prices for rooftop solar PV are expected to continue to decrease over time, but at a decreasing rate (see Figure 5.11) — for instance, the reduction in prices from 2022 to 2023 in CSIRO's GenCost current policies scenario is projected to be 4 per cent, while the projected reduction in prices from 2049 to 2050 is 1.4 per cent.

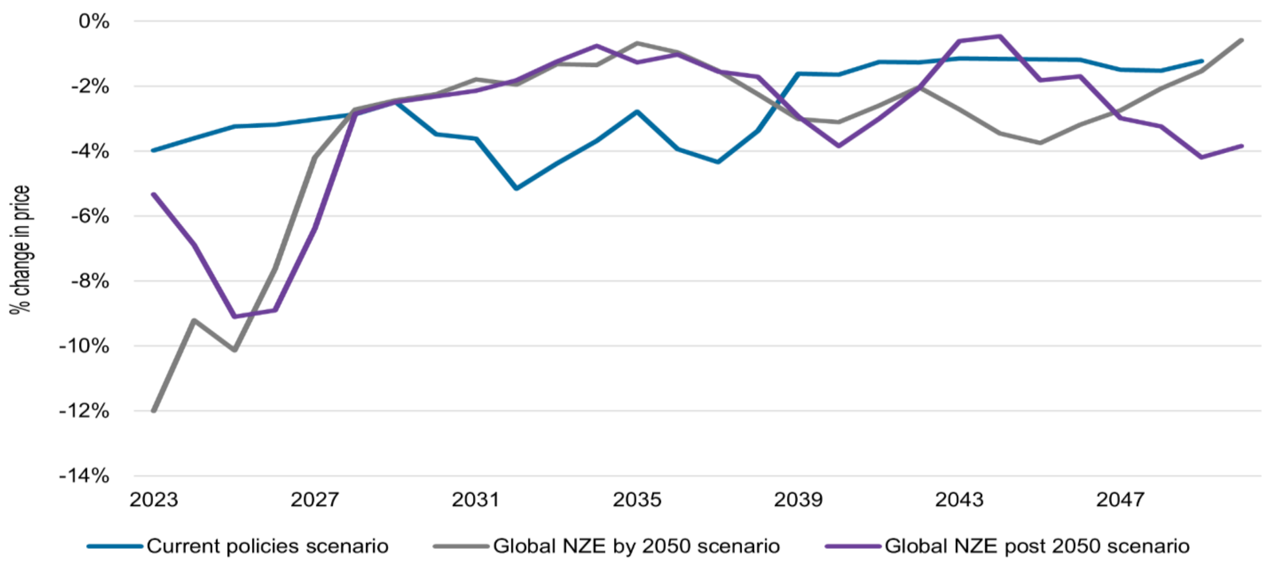
156 LEDinside is TrendForce's LED division which provides intelligence on the global LED industry. TrendForce is a global provider of market intelligence on the technology industries.

157 LEDinside 2018, Global LED Lighting Products Price Trend, https://www.ledinside.com/news/2018/8/global_led_lighting_products_price_trend, accessed 9 December 2021.

Figure 5.10 Retail price of 60-watt equivalent LED lamp products, 2015-2018 (US$)

Source: LEDinside 2018, Global LED Lighting Products Price Trend, https://www.ledinside.com/news/2018/8/global_led_lighting_products_price_trend.

Figure 5.11 Annual change in projected prices of capital costs for rooftop solar PV



Note: The current policies scenario refers to current stated global climate polices, with the most likely assumptions for all other factors such as renewable resource constraints. The Global NZE by 2050 scenario refers to a world that is driving towards net zero emissions by 2050 together with high levels of electrification and hydrogen consumption and trade. The Global NZE post 2050 scenario refers to a world where most developed countries are striving for net zero emissions by 2050 but others are lagging such that global net zero emissions are reached by 2070.

Source: ACIL Allen estimates based on Graham, P., Hayward, J., Foster J. and Havas, L, 2021, GenCost 2021-22: Consultation Draft, Australia, December.

As noted before, when assessing the case for inclusion of learning rates, it is also important to consider:

— that in some circumstances, dwellings constructed under the baseline (i.e. constructed under NCC 2019) would also benefit from declining prices of building products. Where the price declines for inputs that are used under both the baseline and the policy scenario, there would be no change in the incremental cost of achieving higher standards
— that even in cases where the price of energy efficiency inputs used to achieve higher standards fall (but not in the baseline), lower prices may encourage uptake of these products without regulation under the baseline (this is the case with PVs as noted by HIA, and hence considered in the baseline in the form of increased penetration of PV over time)
— whether input price reductions are driven by regulatory reform, in particular increased NCC stringency (i.e. whether changes in prices would not occur without changes to the NCC). This could occur where changes to NCC requirements lead to 'market transformation', such as where widespread uptake leads to declining prices and/or innovations are made to designs in response to more stringent regulation
— that learning rates, where they exist, reach a peak at a point in time and does not continue indefinitely. For instance, the passive solar houses evaluated in the TIC report showed significant cost savings. These savings provide an upper limit to a design learning rate (that is, the savings achieved in these dwellings show an upper limit of the savings that can be achieved through design improvements only - provided the lot allows solar access). There are similar upper limits to materials' learning rates (e.g. LEDs).

Overall, after considering the feedback and evidence provided during consultation, we consider that:

— there is enough evidence on learning rates of rooftop solar PV. That said, it is acknowledged that the rate at which these prices are falling is declining over time
— it is possible that the proposed regulatory changes to the stringency of the energy efficiency requirements in the NCC would drive increased market penetration of high performance glazing products and result in increased economies of scale
— there is no strong evidence to support a more general learning rate on other energy efficiency inputs.

Given this, the following approach for learning rates have been taken for the DRIS:

— learning rates of rooftop solar PV continue to be included in the analysis, but have been updated using the latest data from CSIRO's GenCost report
— based on feedback from the glazing industry, the following reductions are incorporated in the analysis for glazing costs
  – 8 per cent over the first 5 years of the regulation
  – 2 per cent over the last 5 years of the analysis timeframe
— zero learning rates are continued to be assumed for other costs.

The effect of further decreases in overall upgrade costs was tested via sensitivity analysis.

5.5 Benefit assessment

This section describes some of the assumptions and inputs used to estimate the benefits of the proposed changes to the NCC 2022 energy efficiency requirements. Benefits that have not been quantified for the purposes of this RIS are discussed in Section 9.1.

5.5.1 Changes in dwelling energy consumption

Energy flows for dwellings under the BAU and the different upgrade pathways outlined in Section 5.3.6 were estimated by EES and TIC. These energy flows take into account the energy generated by the solar PV systems and used within the dwelling. More information about how these energy flows were estimated is provided in EES's and TIC's reports, *NCC 2022 Update - Whole-of-Home Component* (May 2021) and *Cost and Benefits of upgrading building fabric from 6 to 7 stars* (September 2020).

The difference in energy flows between NCC 2019 and NCC 2022 compliant dwellings is used in this analysis as the basis for estimating the benefits associated with the proposed changes in the energy efficiency provisions.

The estimated change in energy consumption for Class 1 and Class 2 buildings under the different upgrade pathways outlined in Section 5.3.6 are provided in the next chapter.

Are modelled reductions in energy consumption achieved in practice?

The energy performance gap

The difference between actual and modelled/calculated energy is called the 'energy performance gap'.

As noted by CIE[158], 'several international studies have found that there has been a tendency for the energy modelling relied on to estimate energy savings in some CBAs of energy efficiency policies to overstate actual energy savings'. In its 2005 public inquiry into energy efficiency[159], the Productivity Commission also noted its concern that the analytical basis for energy efficiency regulations (computer simulations of energy loads within buildings in each climatic zone) may be flawed.

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[158] Ibid, p. 73.

[159] Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Productivity Commission Inquiry Report No.36, 31 August 2005, p. XXXVIII.

The concerns that modelled energy savings may not be fully realised have been noted by several studies.

- A study of 90 buildings that have achieved a LEED[160] rating in the US found around an 8 per cent Energy Use Intensity (EUI) difference for all of the buildings. The study included both buildings with 'normal' expected uses and some high energy intensity buildings. High energy use buildings (laboratories, data centres and health care) consumed nearly 2.5 times the predicted energy.[161]
- In 2011 the Carbon Trust examined the gap between design predictions and real performance of 28 low carbon buildings (covering many sectors, including retail, education, offices and mixed-use buildings) from the UK Department of Energy and Climate Change Low Carbon Buildings Programme and found that the average gap was about 16 per cent higher operational energy consumption than predicted performance.[162]
- A paper examining existing data on 3,400 German homes and their calculated energy performance ratings (EPR) against the actual measured consumption found that occupants consume, on average, 30 per cent less heating energy than the calculated rating. This phenomenon increases with the calculated rating. The opposite phenomenon, the rebound effect, tends to occur for low-energy dwellings, where occupants consume more than the rating.[163]
- Majcen, Itard, and Visscher's report on a large-scale study of around 200,000 dwellings in Netherlands comparing theoretical energy use with data on actual energy use shows that energy efficient dwellings consume more energy than predicted.[164]
- A report investigating how multi-unit residential buildings in Toronto use energy and how energy models differ from actual building energy performance found that buildings used 13 per cent more energy than predicted by modelling.[165]
- A Canadian study assessing how well 10 LEED Gold certified social housing buildings in Victoria performed in practice found that two had better actual performance then modelled (1.5 per cent to 29.3 per cent less energy), whereas the other eight consumed between 22.1 per cent and 281.7 per cent more energy than models predicted.[166]

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[160] LEED, or Leadership in Energy and Environmental Design, is the most widely used green building rating system in the US administered by the US Green Building Council.

[161] Frankel, M., and C. Turner 2008, *How Accurate is Energy Modeling in the Market?,* Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, California, August, http://newbuildings.org/sites/default/files/ModelingAccuracy_FrankelACEEE2008_0.pdf.

[162] Carbon Trust 2011, *Closing the gap: Lessons learned on realizing the potential of low carbon buildings. Carbon Trust*, London.

[163] Sunikka-Blank, M. and Galvin, R. 2012, *Introducing the prebound effect: The gap between performance and actual energy consumption*, Building Research & Information, 40(3), 260–273.

[164] Majcen, D., Itard, L. C. M., & Visscher, H. 2013, *Theoretical vs. actual energy consumption of labelled dwellings in the Netherlands: Discrepancies and policy implications*. Energy Policy, 54, 125–136.

[165] Sidewalk Labs 2019, *Sidewalk Labs Toronto Multi-unit residential buildings study: energy use and the performance gap*, https://storage.googleapis.com/sidewalk-toronto-ca/wp-content/uploads/2019/06/20224649/SWTO-MURB-Study_-Energy-Use-and-the-Performance-Gap.pdf.

[166] Zhou, Q. and Mukhopadhyaya, P. 2020, *Design Versus Actual Energy Performance in Social Housing Buildings*, https://www.bchousing.org/research-centre/library/building-science-reports/design-vs-actual-performace-social-housing&sortType=sortByDate.

— In terms of commercial buildings, the CIE analysis for the 2018 Decision RIS for energy efficiency of commercial buildings in the NCC 2019 concluded that:

> Overall, the available (albeit limited) Australian evidence suggests that modelled energy savings are unlikely to be fully realised. This finding is consistent with a number of international studies.[167]

Furthermore, the CIE analysis concluded that there was a case for assuming that, on average, between 25 per cent and up to 50 per cent of modelled savings were not realised.

Given the potential noted above for modelled energy savings to not be realised in practice, in Section 7.4.1 we present sensitivity analysis that shows how the modelled impacts of the proposed NCC changes could vary under two alternative realisation scenarios:

— a low realisation scenario where we assume that 50 per cent of modelled energy savings are achieved in practice

— a medium realisation scenario where we assume that 75 per cent of modelled energy savings are achieved in practice.

Rebound energy consumption

As noted by the International Energy Agency (IEA): [168]

> One of the most persistent challenges in energy efficiency policy is accounting for the phenomenon known as the "rebound effect" – where improved efficiency is used to access more goods and services rather than to achieve energy demand reduction. As a result, actual energy demand reductions often fall short of the estimates made during the policy development phase.

The rebound effect is generally driven by one of three things:

1. the take-back effect, where energy users increase their consumption of energy using services (e.g. heating)
2. the spending effect, where energy users spend financial savings from energy efficiency on other energy consuming activities
3. the investment effect, where investment in energy efficiency leads to an indirect increase in economic activity and energy consumption.

The energy efficiency literature often makes note of this rebound effect as a contributing explanatory factor for the differences between projected and actual energy savings.

Empirical evidence suggests that the rebound effect is real. However, the evidence also suggests that the magnitude of the effect is highly variable and context specific (see Table C.1 in Appendix C for a summary of studies into the size and nature of the rebound effect).

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[167] Centre for International Economics (CIE) 2018, *Decision Regulation Impact Statement, Energy Efficiency of Commercial Buildings*, prepared for the Australian Building Codes Board, 13 November, p. 77.

[168] International Energy Agency (IEA) 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency, accessed 2 March 2021, page 39.

To ensure that the analysis is realistic in terms of the estimates of reduced energy consumption and the associated reductions in energy costs and GHG emissions, we have assumed a rebound effect of 10 per cent across all fuels (based on the lower bound estimates outlined by IEA[169] and the assumption that the take-back effect in 6 star new buildings is likely to be relatively small given that they already provide are relative high level of thermal comfort). This in effect means that the projected energy savings from the proposed changes to the NCC are discounted by 10 per cent, resulting in lower GHG abatement and lower bill savings.

Notably, the possibility that a portion of the projected energy savings stemming from the proposed changes to the NCC may not be realised does not necessarily imply that the proposed policy is ineffective. It implies that some of the benefits from the changes are not delivered in the form of energy cost or GHG emissions reductions, but as other type of welfare improvements for society[170]. As noted by IEA: [171]

> Where energy savings are taken back in the achievement of health benefits, poverty alleviation, improving productivity or reducing supply-side losses, the rebound effect created can be viewed as a net positive outcome, amplifying the benefits of the energy efficiency intervention. Often a rebound effect actually signals a positive outcome from the perspective of broader economic and social goals.

Several submissions provided during consultation provided critiques of the handling of the rebound effect in the analysis. These arguments are of three types:

— Energy efficiency makes it cheaper to heat or cool homes, which will induce additional demand. This implies that there is a rebound effect of greater than 100 per cent.

— There is no evidence for a rebound effect or the case has not been made that it should be 10 per cent.

— A rebound effect of any percentage implies a willingness-to-pay for an equivalent dollar amount of energy, which represents amenity for householders that should be included in the cost benefit analysis. This is the argument of the New England Greens and Renew submissions.

There is ample evidence of the rebound effect in energy use in broader contexts. The effect was first identified as Jevon’s Paradox — where the efficiency of coal engines lead to explosive growth in their use during the 1860s industrial revolution. The efficient use of many resources in modern life has increased, inducing demand. Modern examples include batteries, mobile data, road congestion and computing power.

[169] International Energy Agency (IEA) 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency, accessed 2 March 2021, page 39.

[170] Notably, as discussed in Section 4, the objective of the energy efficiency requirements in the NCC have been broadened to include occupant health and amenity (in addition to reductions in GHG emissions).

[171] International Energy Agency (IEA) 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency, accessed 2 March 2021, page 39.

In economic terms, the rebound effect is a realisation of the substitution and income effects. The lowering of cost of a consumed good increases all consumption (the income effect) and increases the consumption of that good (the substitution effect). Thermal comfort would need to have perfectly inelastic demand (not bound by the substitution effect or income effect) or be a Giffen good[172] (where increases in price increases demand) for no rebound effect to take place. In reality, a rebound effect of some magnitude is almost guaranteed in almost all similar circumstances.

The degree to which the rebound effect applies in residential properties is ultimately an empirical question. It is highly likely that the effect varies considerably between households, across individuals' preferences, and across household energy efficiency ratings. For example, installing a more efficient heater in a poorly-insulated house may increase usage, whereas installation of the same heater in a well-insulated house would be unlikely to improve amenity, and efficiency will be captured as decreased energy costs. Householders may improve their thermal comfort if houses become more efficient — alternatively they might worry less about energy costs and heat their homes while windows are left open.

As noted before, several studies suggest that the rebound effect is greatest when the starting point is low energy efficiency. However, studies also note that the type of energy saving, the location, the time and the study cohort all make an impact (see Table C.1 in Appendix C).

A detailed interventional study in the Australian context would be required to provide an accurate estimate of the average rebound effect. However, as noted above, the existing studies suggest a rebound effect of around 10 per cent, particularly for highly efficient households (above 7 stars) is appropriate.

There is some merit in the argument presented in submissions that there is amenity represented in the rebound effect equal to or greater to the value of the energy saved. In traditional economic modelling, householders will increase their amenity to the point where the marginal unit of thermal comfort is equal to the marginal value of the lost energy savings.

In reality, there is a technical rate of substitution between energy savings/spending and increased amenity. Including an accrued benefit exactly equal to 10 per cent of the energy savings implies a linear transformation — a one-for-one transformation. The actual technical rate of substitution may be concave or convex — more- or less-than one-for-one. This means it is impossible to know whether the 10 per cent accrued amenity is a lower or upper bound. Without a separate study, it is speculative which way it would go.

Reflecting stakeholder feedback that this amenity should be considered, the DRIS CBA modelling will include an offsetting 10 per cent amenity benefit to match the rebound effect. The rebound effect will be maintained, as aside from any amenity value, it also decreases the carbon emissions saved and network effects of the induced demand.

[172] Giffen goods are a conceptual tool. Evidence that they exist is scarce and is contentious. Examples include low-quality food during a famine.

5.5.2 Offset and export of electricity generated by solar PV

EES estimated the electricity generated from solar PV systems installed as a result of the proposed changes to the NCC 2022. If the annual electricity generated by the solar PVs for a dwelling is less than the dwelling's total electricity demand, then it is used to offset the electricity demand of the dwelling. When a large solar PV system is installed that produces surplus electricity from household demand, the additional energy generated is assumed to be exported to the electricity grid.

The solar PV exports to the grid have been treated in the following way for this analysis at an economy-wide level:

— estimates of the *quantity* of energy saved (in PJ) due to the proposed changes in the NCC 2022 include solar PV exports, with the *value* of these solar PV exports based on the solar dispatch weighted wholesale electricity price

— estimates of the *quantity and value* of GHG emissions saved due to the proposed changes in the NCC 2022 account for the additional benefits generated by solar PV exports, as these exports would displace coal- (or gas-) generated electricity and hence effectively reduce emissions

— estimates of the *value* of health benefits generated by reductions in coal and gas generated electricity due to the proposed changes in the NCC 2022 account for the additional benefits generated by solar PV exports, as these exports would displace coal- (or gas-) generated electricity and hence effectively reduce emissions.

The income generated from solar PV exports to households has been accounted for in the distributional (household) analysis in Chapter 8.

Notably, the WoH modelling undertaken by EES includes the retail value of PV exports (feed-in tariffs) in the calculation of the societal cost of energy which is used to set the stringency of the NCC energy efficiency requirements (the income generated by exports to the grid is treated as a cost offset). Feed-in tariffs are expected to decrease significantly over the next few years (see Figure 5.17), which would effectively increase the stringency of the proposed WoH requirements under Option A over time. At the extreme, if feed-in tariffs were zero, there would be no income from PV exports to offset the societal cost of energy of a house. Additional measures would then need to be taken to achieve savings equivalent to 30 per cent of the societal cost of the benchmark building specified in Option B.

As the value of feed-in tariffs is an input set by EES's WoH modelling, we are unable to conduct sensitivity analysis to test the effect of changes in these feed-in tariffs on the energy flows and costs for individual dwellings.

5.5.3 Energy prices

Electricity and gas

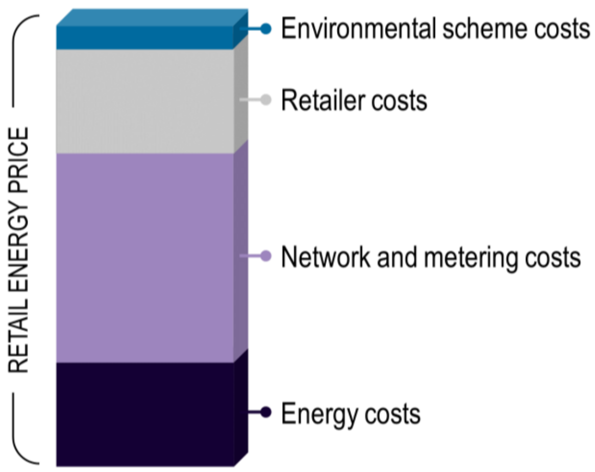
Any reductions in energy consumption as a result of the proposed interventions would generate benefits to households in the form of reduced energy bills, and at the economy-wide level as a result of a reduction in the overall energy consumed. As such, to estimate the impacts of the proposed changes, it is necessary to have baseline estimates of future energy prices.

Approach to valuing energy savings

In calculating the value of energy savings, it is critical to not confuse economy-wide benefits with distributional impacts. For example, the economy-wide benefits of energy efficiency are often misconstrued to include the reduction in retail electricity bills experienced by the customer as a result of their decreased energy usage. It is true that, from the customer's point of view, this reduction represents a benefit. However, there is an equal and opposite reaction with some of the reductions in costs for these customers redistributed to other customers. For example, total network costs would only be reduced if network augmentation can be deferred or avoided. Additionally, many of the retail costs of energy (such as costs associated with call centres, revenue and billing collection, customer acquisition and retention, and IT systems) are driven by the number of customers, not by energy consumption. From the perspective of energy efficiency, these types of costs are 'fixed'.

The retail energy price broadly comprises four components as illustrated in Figure 5.12.

Figure 5.12 Components of the retail energy price



Source: ACIL Allen

The energy cost component comprises a fixed component (capital and fixed operating and maintenance costs) and a variable component (fuel and variable operating and maintenance costs). In the short run, the variable fuel and operating costs are avoided when energy usage is reduced. Wholesale energy price projections are used as a proxy representing the marginal cost saving associated with the reduced energy from investments in energy efficiency measures in the residential building stock. In the long run, investment in new generation capacity may be deferred or avoided.

The network costs are driven by the size (capacity) of the network and the metering costs are driven by the number of customers; they are not driven by energy usage unless that energy usage occurs at the time of peak demand in a location where the network is constrained.

The electricity distributors' revenues are regulated in accordance with a revenue cap – that is, the revenue is fixed in the short term. In the longer term, total network costs would only reduce if:

— there is a deferral in the augmentation of the network, which would only occur if the reduction in energy is at the time of peak demand on the network and in the location where the network is constrained
— the expenditure for replacing the network can be reduced by replacing network components with lower capacity components.

The retailer costs comprise the retailer's operating costs and margin. The retailer's operating costs (call centres, revenue and billing collection, customer acquisition and retention, and IT systems) are driven by the number of customers rather than the energy used. These costs would not change as energy usage decreases through the additional energy efficiency requirements in the NCC 2022.

It is generally assumed that the margin is a percentage applied to the other costs. If energy costs decrease, then the operating margin applied to those costs would also decrease. However, any change in the retail margin represents a transfer of costs – any benefit to the household is a cost to the retailer.

Most of the environmental scheme costs are fixed based on a fixed target that is allocated on the basis of energy usage. As such, the amount recovered per unit of energy used increases as energy usage decreases. The societal costs associated with environmental schemes are not reduced as energy usage reduces with more stringent energy efficiency requirements, unless the target changes.

In light of the above discussion, to assess the societal benefit of a reduction in the energy used by new buildings due to the changes in the NCC in 2022, we considered the components of the retail prices that would result in a reduction in costs incurred by society – the avoided wholesale energy costs (as a proxy for the avoided resource costs) and the avoided generation and network investment. That is, to assess the economy-wide energy benefits of the scheme we use a capacity and network approach which valued the avoided energy costs based on the avoided wholesale electricity prices and the avoided generation and network investment (discussed in more detail in Sections 5.5.4, 5.5.5 and 5.5.6).

This approach is consistent with the Australian Government's handbook on cost-benefit analysis, which states:

> One of the first tasks for the analyst is to distinguish the allocative effects of a project, that is, the effects due to changes in the use of resources and in outputs, from the distributional effects. Generally speaking it is only changes in resource use that involve opportunity costs. Distributional effects may be regarded as 'transfers' – that is, some individuals are made better off while others are made worse off. Distributional effects do not add or subtract from estimated net social benefit. However, they may affect social welfare if the judgement is made that one group derives more value from the resources than another group.[173]

The distributional effects referred to in the handbook on cost-benefit analysis would be included in the economy-wide cost benefit analysis if retail electricity prices had been used.

[173] Australian Government, *Handbook of Cost-Benefit Analysis*, January 2006, page 27.

Similarly, the April 2017 Houston Kemp report for the Australian Government *Residential Buildings Regulatory Impact Statement Methodology* recognises that retail electricity prices were historically used to value the energy savings from energy efficiency activities from a societal perspective, which is not accurate. It states that:

> Previous studies have used reduction in the retail bill as the benefit, which represents the financial savings to households based on existing tariffs. However, we believe a more accurate approach is to estimate the resource cost savings from reduced electricity and gas consumption, i.e., reduction in network and wholesale costs.[174]

And that:

> To estimate the benefit from reductions in electricity generation costs, average wholesale market prices can be used as they typically represent suitable estimates for the resource cost savings.[175]

Following the release of the Houston Kemp report, the energy savings from energy efficiency activities have more commonly been valued at a societal level using avoided wholesale and network costs rather than by using retail prices,[176] although retail prices continue to be used to assess the impact at a household level, as discussed in the next section.

Response to feedback from stakeholders

Several stakeholders provided feedback about the approach taken in the CRIS to value the energy savings at the societal level. PCA, ASBEC, GBCA and EEC support in principle the use of the 'capacity and network approach' to valuing benefits and agree that it is inappropriate to use retail prices. However, they are of the view that the following retail costs are avoidable at the margin in a competitive market – inefficient costs, excessive profit margins and contributions to the nRET scheme.

Conversely, Renew, New England Greens and another submission are of the view that the use of wholesale electricity prices rather than retail electricity prices undervalues the benefits. Submission ANON-7GZH-JXVR-A argues that using wholesale prices is unsuitable as householders do not have access to wholesale energy prices and that using these prices 'represent gentailer investors ahead of the general public as society'[177].

Submission ANON-7GZH-JXFC-B argues that the CRIS understates the benefits of the proposed changes. In particular, they refer to the CRIS argument that energy charges that are reduced for new households, but which do not result in costs being avoided, are transferred to other energy users through higher energy prices. While this submission acknowledges that 'it is correct to say that for an existing dwelling a reduction in electricity use results in fixed costs being recovered over a smaller

[174] Houston Kemp, *Residential Buildings Regulatory Impact Statement Methodology,* 6 April 2017, page 14.

[175] Ibid, page 15.

[176] Prior to the release of the Houston Kemp report, the avoided wholesale and network cost approach was used for some analyses but not all.

[177] Submission ANON-7GZH-JXVR-A, p.2.

energy base'[178] they argue that this is not true for new dwellings as new housing expands the energy consumer base.

In addition, it was suggested that the DRIS should consider the benefits to electricity customers more broadly through the reduction in the wholesale electricity price and the flow through to retail electricity prices. This analysis will also need to consider the increase in retail electricity prices through the re-distribution of network costs and the costs associated with environmental schemes.

The CRIS assessed the impacts of the proposed energy efficiency provisions in NCC 2022 from two perspectives – from the perspective of:

— households that are subject to the proposed NCC 2022 provisions
— the economy more broadly.

The DRIS analysis at a household level continues to value the benefits associated with reductions in energy use based on retail energy prices, consistent with the CRIS.

The benefits of the energy efficiency provisions in the NCC 2022 at an economy-wide (societal level), include the costs that are avoided by society as a result of the changes to the NCC 2022. That is, the benefits include costs that will no longer be incurred as a result of the proposed energy efficiency provisions in the NCC 2022. They do not include costs that are shifted from one party to another – while these are a benefit to one party, they are a cost to another party. The net impact on the economy of these redistributions of costs is zero.

If retail energy prices were cost reflective, the reduction in the household energy bills (excluding the profit margin) would reflect the reduction in costs at a societal level. However, as retail energy prices are not cost reflective, a different approach must be used to value the benefits at a societal level. The analysis needs to consider the components of the retail energy prices that are avoided by society as a result of the proposed energy efficiency provisions in the NCC 2022.

The electricity-related costs that are avoided by society are:

— the variable operating and maintenance costs (including fuel costs) that would otherwise be incurred to produce energy
— the deferral costs if investment in new generation capacity can be deferred
— the deferral costs if new network capacity can be deferred
— the costs that would otherwise be incurred to operate and maintain the network capacity that is deferred.

The wholesale electricity price was used in the CRIS as a proxy for the variable operating and maintenance costs (including fuel costs) that would otherwise be incurred to produce energy. The use of the wholesale electricity price overstates these avoided costs. That is, the benefits are overstated.

[178] Submission ANON-7GZH-JXFC-B, p.2.

ACIL Allen's energy market modelling identified that generation capacity would be brought forward as a result of the proposed NCC 2022 energy efficiency provisions. The additional cost associated with this brought forward investment is discussed further in Section 5.5.4.

The deferral costs of new network capacity were estimated and the operating and maintenance costs associated with the deferred network investment are discussed further in Sections 5.5.5 (electricity) and 5.5.6 (gas).

In a competitive market, the retailers should not incur inefficient costs or excessive profit margins that are avoided through the NCC 2022. An assessment of the competitiveness of the retail electricity market is beyond the scope of this RIS, noting that retail electricity prices for households are set by governments or regulators in some jurisdictions and are subject to price caps set by regulators in other jurisdictions.

The two key environmental schemes are the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). The LRET scheme is designed so that a certain number of certificates is required to be surrendered in each year. The costs associated with these certificates and those for the SRES are recovered from all customers – the costs are not avoided by the NCC 2022 as a cumulative adjustment applies for any variances from prior years.

The base of consumers is growing under both the base case and the policy scenarios – the policy options do not change the size of the customer base and therefore there is no benefit that accrues from a change in the base of consumers.

After reviewing the feedback received during consultation, it was concluded that the DRIS continues to:

- value the benefits associated with reductions in energy use at a household level based on retail energy prices
- value benefits of the proposed provisions at an economy-wide or societal level using wholesale energy prices and avoided generation and network investment. The use of wholesale energy prices as a proxy for the variable operating and maintenance costs (including fuel costs) that would otherwise be incurred to produce energy, in fact, overstates the costs that are avoided by society as a result of the changes to the NCC 2022 (i.e. the benefits are overstated).

However, in response to the feedback, the DRIS considers the distributional impact to electricity customers more broadly from the change in the wholesale electricity price and the flow through to retail electricity prices.

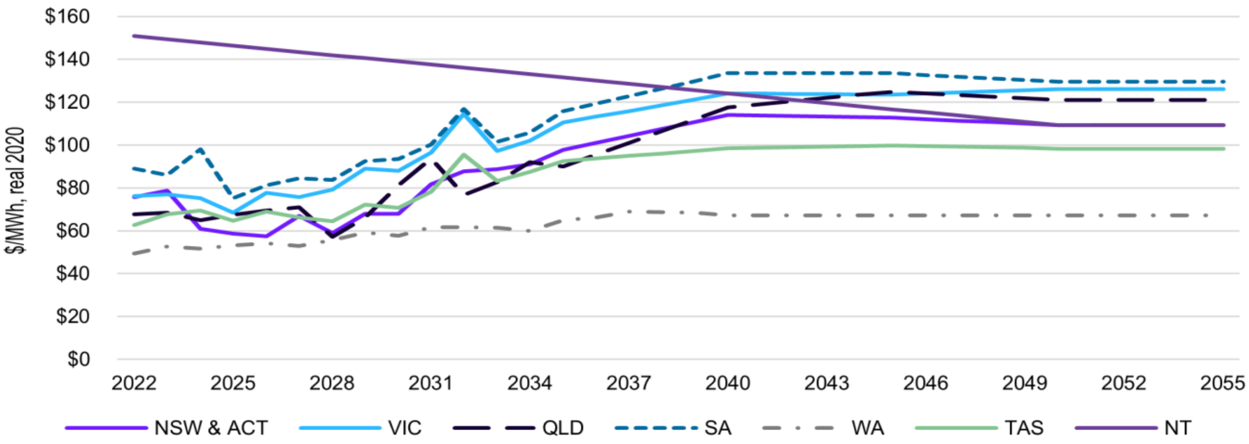
Wholesale prices for economy-wide analysis

The wholesale electricity and gas price projections used in the analysis, other than the wholesale electricity prices in the NT, were generated by our proprietary PowerMark and GasMark models of the wholesale gas and electricity markets. Additional information about these models is provided in Appendix J and our projections of wholesale electricity and gas prices are shown in Figure 5.13 and

Figure 5.14.[179] The wholesale electricity price in the NT in the start year was estimated based on the AEMC's report on residential electricity price trends, with the prices decreasing over time as the NT wholesale electricity market is transformed. These prices have been updated from the CRIS based on updated energy market modelling.

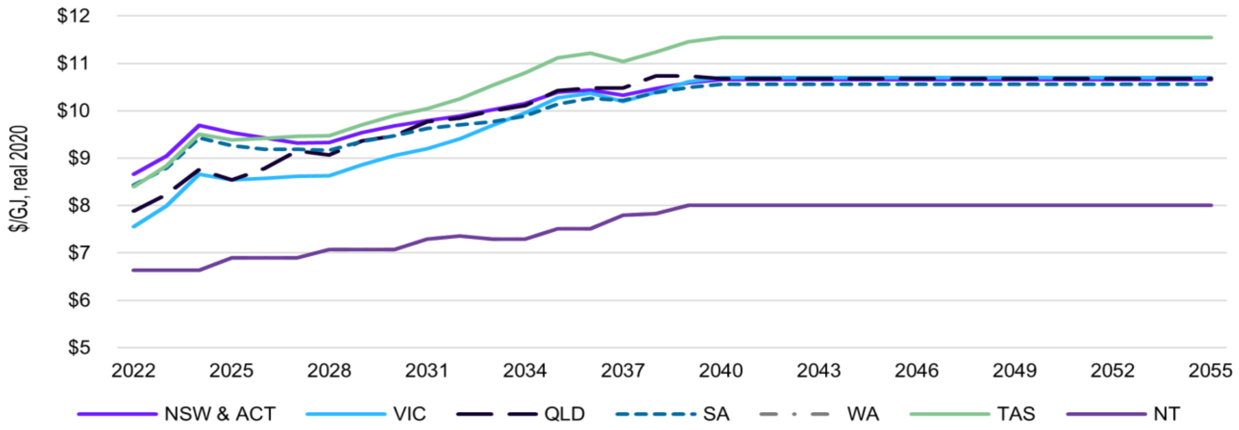
We note that the use of the capacity and network approach results in BCRs and NPVs that are much smaller than if retail energy prices are used. In effect, there is a redistribution of costs from the occupants of a dwelling with increased energy efficiency to other energy users because of the fixed costs discussed above.

Figure 5.13 Wholesale electricity price projections, $ per MWh



Source: ACIL Allen.

Figure 5.14 Wholesale gas price projections, $ per GJ



Source: ACIL Allen.

179 We undertook wholesale electricity market modelling in the National Electricity Market (NEM) and the Western Australian Electricity Market (WEM) to assess the impacts of the proposed NCC 2022 on the energy market. The projected wholesale electricity prices from that modelling for the jurisdictions in the National Electricity Market and Western Australia were used for this RIS. The projected wholesale electricity prices for the Northern Territory and the projected wholesale gas prices were based on previous modelling undertaken by ACIL Allen.

The load-weighted wholesale electricity prices projected by *PowerMark* were used to value the distributional effect of a change in wholesale electricity prices on all electricity customers. The distributional impact was estimated using the same demand projections as assumed for the energy market modelling, as discussed in Appendix K.

Retail prices for distributional analysis

As is standard practice, the CBA of the changes proposed in NCC 2022 was undertaken from the perspective of the broader Australian community, with impacts that are transfers between stakeholders (such as between the government and households, and between households that would be subject to the additional energy efficiency requirements and those that would not) netted out. Nevertheless, it is important to consider the implications of some of these transfers on stakeholders, particularly the implications of energy bill reductions on households.

As such, we have also included a distributional analysis in the RIS that shows the expected impacts of the proposed changes on households that are subject to the changes. In contrast to the economy-wide analysis, this household analysis is done using retail energy prices.

The retail electricity and gas prices used for the analysis of the impacts of the modelled scenarios on households are shown in Figure 5.15 to Figure 5.17. These were based on a number of sources as follows:

— for retail electricity prices:
  – other than for WA and NT, we used the average retail prices from AEMC Residential Electricity Price Trends 2020 Final Report[180] for the start year and projected the change in these prices over time using information sourced from our proprietary model *PowerMark* on the change in the wholesale electricity cost component and assumed the remaining components of the retail electricity price remained constant in real terms. Reflecting feedback received by Renew, these tariffs were adjusted to exclude daily fixed charges (the AEMC tariffs used in the CRIS prorate the daily (fixed) charges into variable charges)
  – for WA[181] and NT[182], we used the current regulated prices
— for retail gas prices we used the average of current market offers (sourced from comparison sites) for the start year and projected the change in these prices over time using information sourced from our proprietary model *GasMark*
— other than for WA and NT, we used the average retail prices from AEMC Residential Electricity Price Trends 2020 Final Report183 for the start year and projected the change in these prices over time using information sourced from our proprietary model *PowerMark* on the change in the wholesale electricity cost component and assumed the remaining components of the retail electricity price remained constant in real terms
— feed in tariffs to value exports to the grid for all jurisdictions except the NT were estimated/projected using the average of the annual large-scale solar dispatch weighted

[180] AEMC*, Residential Electricity Price Trends 2020, Final report*, 21 December 2020.

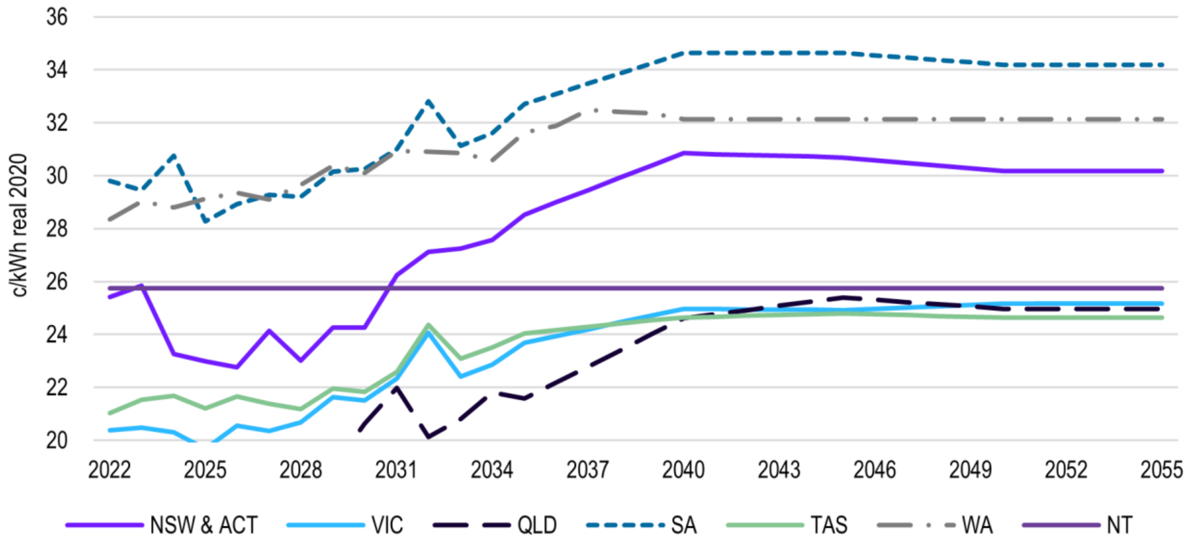
[181] https://www.wa.gov.au/organisation/energy-policy-wa/household-electricity-pricing

[182] https://utilicom.nt.gov.au/__data/assets/pdf_file/0012/1020027/Electricity-Pricing-Order-1-July-2021-30-June-2022.pdf

[183] AEMC*, Residential Electricity Price Trends 2020, Final report*, 21 December 2020.

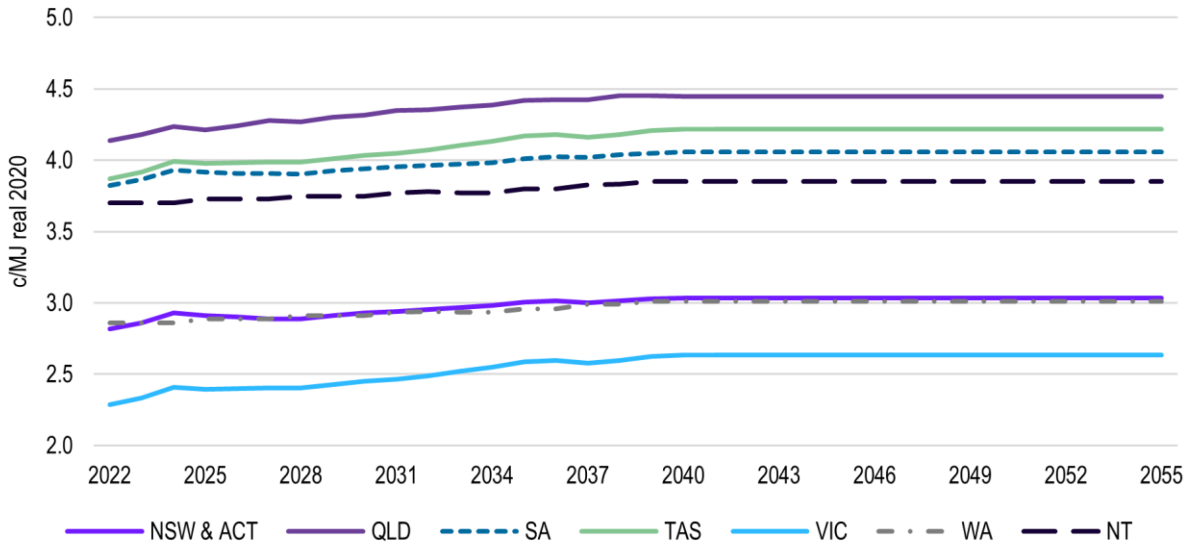
wholesale electricity price in each jurisdiction plus 6 per cent, which represents loss factors that the retailer will pass onto the end consumer. For the NT, tariffs were set at the current standard regulated tariff (8.3 c/kWh ex GST184).

Figure 5.15 Retail electricity prices, cents per kWh



Source: ACIL Allen.

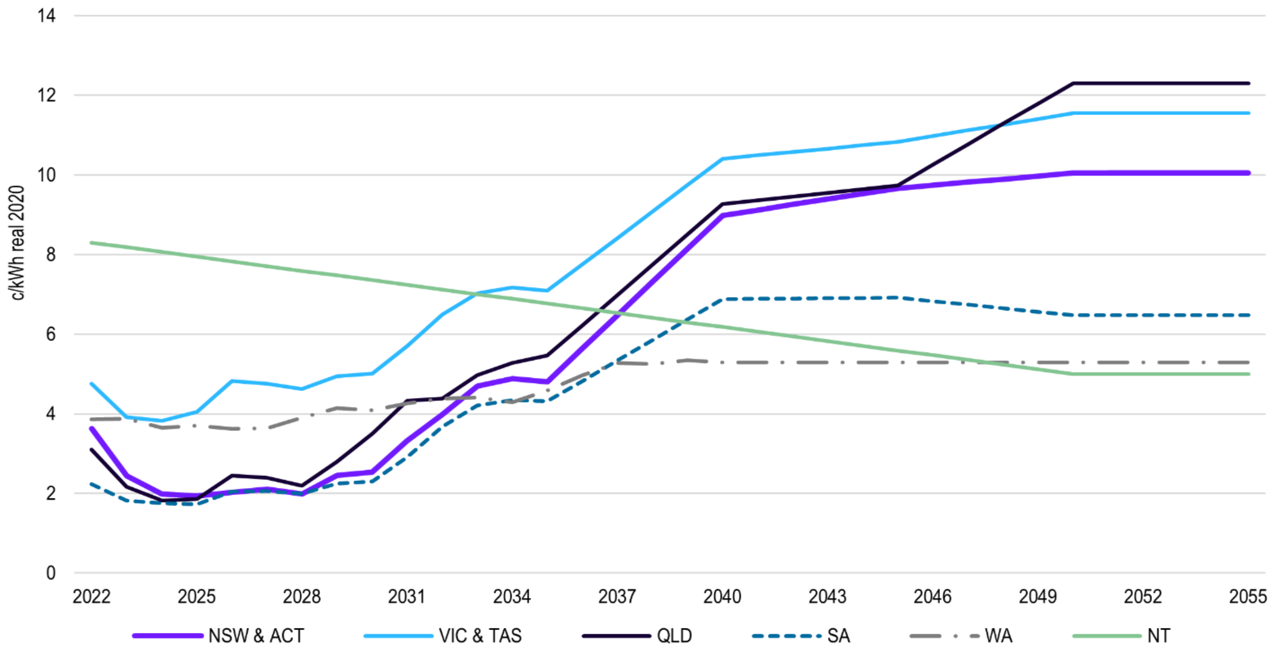
Figure 5.16 Retail gas prices, cents per MJ



Source: ACIL Allen.

[184] https://industry.nt.gov.au/__data/assets/pdf_file/0008/811628/changes-to-feed-in-tariffs-fact-sheet.pdf

Figure 5.17 Feed in tariff for PV exports to grid, cents per kWh



Source: ACIL Allen.

Wood and LPG

Retail firewood prices for the CBA have been assumed to be the same as in EES's modelling – $1.85 cents per megajoule (MJ)[185]. For the economy-wide analysis it has been assumed that the resource cost component of these prices is 75 per cent (i.e. that the wholesale firewood prices are 75 per cent of retail prices). Prices are assumed to remain constant in real terms over the analysis period.

Retail LPG prices for the CBA were sourced from comparison sites. For the economy-wide analysis it has been assumed that the resource cost component of these prices is 75 per cent (i.e. that the wholesale LPG prices are 75 per cent of retail prices). Prices are assumed to remain constant in real terms over the analysis period and are shown in Table 5.22.

Table 5.22 LPG prices, $2021

Jurisdiction	Wholesale price (c per MJ)	Retail price (c per MJ)
NSW	3.60	4.80
VIC	3.38	4.50
QLD	4.05	5.40
SA	4.35	5.80
WA	4.35	5.80

185 Both for the CBA and distributional analysis.

Jurisdiction	Wholesale price (c per MJ)	Retail price (c per MJ)
TAS	3.98	5.30
NT	3.60	4.80
ACT	4.13	5.50

Note: Prices are assumed to remain constant in real terms over the analysis period.
Source: ACIL Allen based on EES data.

5.5.4 Change in generation investment

While the energy market modelling for the CRIS indicated that there was no change in generation investment with the proposed NCC 2022, the energy market modelling for the DRIS indicated that additional generation capacity is needed in Victoria. Investment in battery storage and gas-fired generation is brought forward, as well as the conversion of gas-fired generation to hydrogen-fired generation.

The changes in generation capacity have been valued using the same capital cost assumptions that were used in the energy market modelling, as discussed in Appendix K.

5.5.5 Deferred electricity network investment

As discussed in Section 5.5.3, the avoided electricity network costs are a function of the reduction in peak demand, and the augmentation expenditure that can be deferred and the replacement expenditure that can be reduced. The deferred electricity network costs have been calculated in two recent analyses relating to energy efficiency[186] by:

1. imputing a reduction in peak demand based on the reduction in energy use by using a conservation load factor (CLF)[187]
2. quantifying the network benefits by applying a dollar value per unit reduction in peak demand.

We have used the same approach to estimate the avoided network costs.

[186] See Strategy. Policy. Research 2018, pp. 38-39 (Strategy. Policy. Research 2018, Inclusion of heating and cooling energy load limits in NatHERS assessments, Regulation Impact Statement for decision, prepared for the Australian Building Codes Board) and Jacobs 2019 pp. 33-34 (Appendix 11 of the Regulatory Impact Statement for the VEU targets by the Department of Environment Land, Water and Planning. Jacobs, 2019 Victorian Energy Upgrades Program, Energy Market Modelling, Final Report, 17 October 2019, https://engage.vic.gov.au/download/document/9826).

[187] The reduction in peak demand is equal to the reduction in energy consumption divided by the number of hours in the year, divided by the conservation load factor.

Imputing a reduction in peak demand

The most recent RIS for energy efficiency in residential buildings[188] to estimate the reduction in peak demand applied a CLF of 0.4 based on a 2011 SKM MMA (now Jacobs) report and a 2012 Oakley Greenwood/ Marchment Hill report. A 2019 Jacobs report provided the CLFs as set out in Table 5.23, which indicate that this figure likely overstates the peak demand reductions (the lower the CLF, the higher the peak demand reductions for a given reduction in energy use).

Based on the CLFs as set out in the 2019 Jacobs report, we applied a CLF of 0.50.

Table 5.23 Conservation load factors

Residential end-use	Basis / Source	Conservation load factor	
		Summer 4 pm peak	Winter 6 pm peak
Building shell upgrade	Summer cooling + Winter heating	0.48	0.50
Residential cooling	RC AC profile	0.48	-
Residential heating	RC AC profile	-	0.50
Residential lighting	Daylight hours & Household occupancy	2.64	0.34
Residential water heating	NZ HEEP study	1.49	1.09
Residential outdoor lighting	Daylight hours & Household occupancy	2.64	0.34
Residential refrigeration	Adjusted cooling profile	0.70	0.90
Televisions and set top boxes	Household occupancy	0.79	0.66
Computers and laptops	Household occupancy	0.79	0.66
Other consumer electronics including mobile chargers, printers et cetera	Household occupancy	0.87	0.73
Other miscellaneous appliances including kettles, toasters, hairdryers, shavers et cetera	Household occupancy	0.83	0.69
Residential pool/spas	Household occupancy, Ergon Energy profile	0.73	0.84

Source: Appendix 11 of the Regulatory Impact Statement for the VEU targets by the Department of Environment Land, Water and Planning. Jacobs, 2019 Victorian Energy Upgrades Program, Energy Market Modelling, Final Report, 17 October 2019, https://engage.vic.gov.au/download/document/9826, p.37

Stakeholders provided feedback on the CLF values used in the CRIS. PCA, ASBEC, GBCA and EEC were of the view that the avoided network benefits were underestimated by applying a CLF that was too high.

The CLFs for a range of residential end-uses, for a summer peak and a winter peak, are set out in the table above. The only residential end uses with a CLF less than 0.50 were for:

— building shell upgrade – CLF of 0.48 in summer (and 0.50 in winter)
— residential cooling – CLF of 0.48 in summer
— residential lighting – CLF of 0.34 in winter.

The CLFs for other residential end-uses were around 0.80, other than lighting in summer which had a CLF of 2.64.

Three of the main drivers of residential energy use – building shell, cooling and heating – have a CLF of 0.48 or 0.50, which indicates that a CLF of 0.50 is reasonable. No evidence was provided during consultation to support a change to this factor.

Quantifying the network benefits

The network benefits have been calculated based on the incremental reduction in peak demand in each year and the capital expenditure that would have been deferred by that reduction in peak demand. In the instances where there is increase in peak demand, the estimated capital expenditure required to meet this have been included.

The deferred transmission network benefits have been estimated using the same transmission deferral benefit as used in the 2019 Jacobs report ($500/kW), escalated from 2019 dollars to 2021 dollars. This value was:

> … based on in-house advice and has been chosen because it conservatively reflects the uncertainty associated with network deferrals, and because the value of transmission deferrals is usually not material.[189]

We have estimated the distribution network benefit using the forecast capital expenditure on load growth in the most recent revenue determinations for each electricity distributor and the forecast growth in peak demand. Based on this data, we have assumed that the costs associated with growing the electricity distribution network are around $3,000/kW, noting that the cost varies widely across electricity distributors as the demand growth is very low or negative in many electricity distribution areas.

Consistent with the 2019 Jacobs report, we have applied a discount factor of 70 per cent to:

> … allow for the uncertainty involved in networks actually being able to recoup the benefits from the programs.[190]

[189] Jacobs, *2019 Victorian Energy Upgrades Program, Energy Market Modelling, Final Report*, 17 October 2019, p.33.

[190] A footnote on page 34 of the Jacobs report indicates that the 70 per cent discount factor was derived from assumptions used in the Department of Climate Change and Energy Efficiency evaluation of a National Energy Saving Initiative.

An additional 10 per cent discount factor was applied in Option A to take into account the additional costs that may be incurred by the electricity distributors to accommodate the higher uptake of solar PV systems under that option.

We have also compared this figure to the electricity distributors' forecast Long Run Marginal Cost (LRMC) for supplying residential customers to ensure that it is reasonable.

Feedback was provided about this approach during consultation. PCA, ASBEC, GBCA and EEC were of the view that avoided operating costs should also be taken into account, and that the avoided network benefits were underestimated by applying the discount factors of 70 per cent and an additional 10 per cent in the case of Option A. New England Greens and Renew were also of the view that the discount factors of 70 per cent and 10 per cent in the case of Option A were too high.

The avoided operating costs associated with the deferred network benefits could be included in the CBA, but the impact will be immaterial.

No evidence was provided by stakeholders as to an alternative value to use to quantify the avoided network investment.

Stakeholders appear to assume that a reduction in energy use will necessarily result in avoided network costs. However, as mentioned before, network costs will only be avoided if:

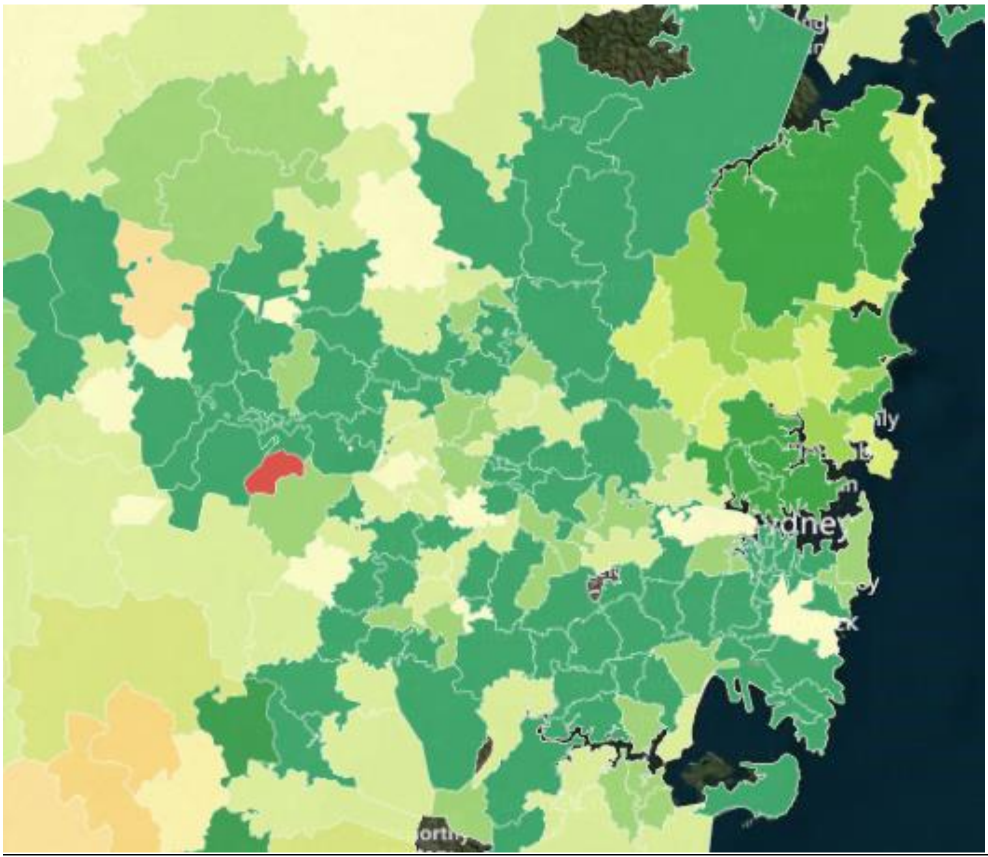
- expenditure would have occurred on the network in the absence of NCC 2022
- the reduction in energy consumption as a result of NCC 2022 is sufficient to defer the expenditure.

Investment can occur at three levels within the distribution network – at the substation level, at the feeder level and at the customer connection level – with decreasing investment required at each level to increase capacity.

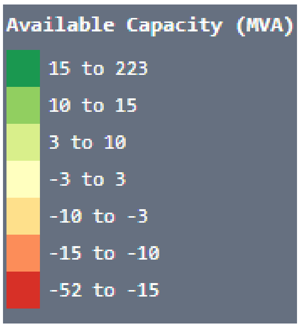
Figure 5.18 provides a map of available distribution capacity at the substation level in Melbourne and Sydney in 2021. Most of Sydney has available capacity at the substation level in the distribution network and therefore expenditure is not required to provide additional capacity in these areas and there is no opportunity for expenditure to be deferred through the proposed energy efficiency provisions in the NCC 2022. There are only a small number of areas in which additional capacity may be required which could be deferred by the proposed energy efficiency provisions in NCC 2022.

Figure 5.18 Available distribution capacity, 2021

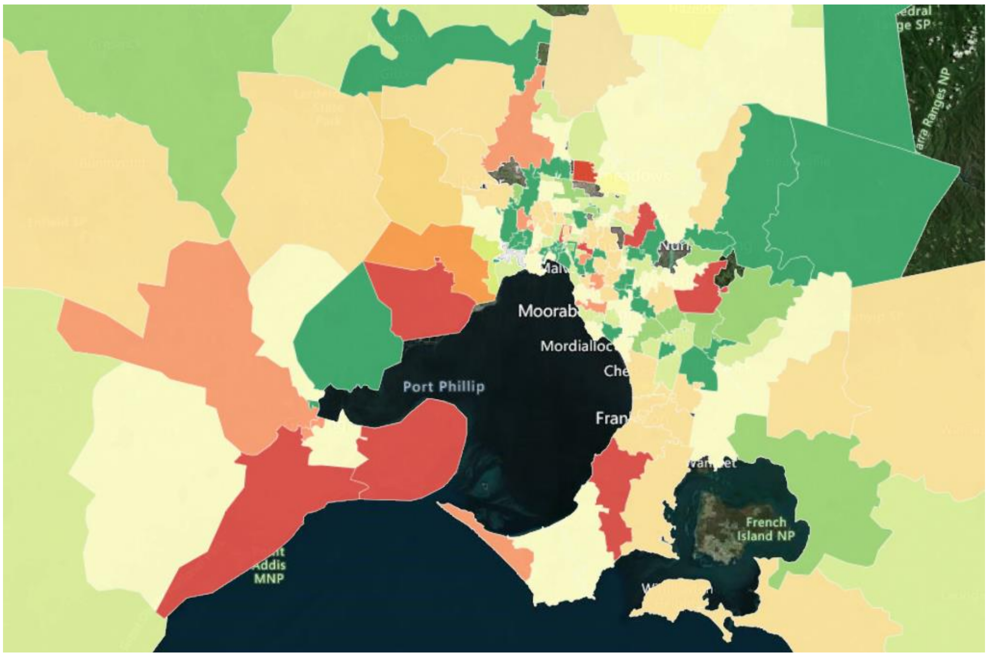
Sydney



Legend



Melbourne



Source: https://nationalmap.gov.au/#share=s-d3L5KSuWrT8eC3Le1rv9DH9Juke, accessed 9 December 2021.

As shown in Figure 5.18, there is significantly less available capacity in the distribution network at the substation level in Melbourne than in Sydney. However, many areas of Melbourne already have insufficient network capacity and will require expenditure, regardless of the proposed energy efficiency provisions in NCC 2022. Other areas have available distribution capacity and therefore expenditure is not required to provide additional capacity in these areas. The number of areas in which there is the potential for the proposed energy efficiency provisions to defer network expenditure are relatively few.

Accordingly, the network benefits would be overstated unless a discount factor is applied.

Similar information is not available at lower levels in the network.

Discussions with stakeholders identified that additional costs are incurred to accommodate solar. For example, the Australian Energy Regulator (AER) has approved the following expenditure for the Victorian electricity distributors over the 2021-26 period to enable them to integrate more solar into the network:

— AusNet Services - $20.9 million for Hosting Capacity to address new export constraints as they emerge[191]
— CitiPower - $18.6 million to upgrade distribution transformers to increase capacity[192]
— Jemena - $8.4 million for targeted investments to increase the network's hosting capacity for distributed energy resources[193]
— Powercor - $35.3 million to upgrade distribution transformers to increase capacity[194].
— United Energy - $13.8 million to upgrade distribution transformers to increase capacity[195]

The assumptions that were used in the CRIS were provided to electricity distribution businesses via an ABCB/DNSP roundtable. Comments were sought on the accuracy of the assumptions, but no comments were received. In the absence of any additional information on the network benefits, including an appropriate discount factor, it is our judgement that it is appropriate to maintain the discount factor as applied in the CRIS.

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[191] AER, *Draft Decision,* A*usNet Services Distribution determination 2021 to 2026, Attachment 5: Capital expenditure*, September 2020, page 5-24

[192] AER*, Draft Decision, CitiPower Distribution determination 2021 to 2026, Attachment 5: Capital expenditure,* September 2020, pages 5-46 to 5-53

[193] Jemena*, 2021-26 Electricity Distribution Price Review – Revised Proposal, Attachment 04-01, response to the AER's draft decision – Capital expenditure,* pages 25 and 28

[194] AER*, Draft Decision, Powercor Distribution determination 2021 to 2026, Attachment 5: Capital expenditure,* September 2020, pages 5-47 to 5-55

[195] AER*, Draft Decision, United Energy Distribution determination 2021 to 2026, Attachment 5: Capital expenditure,* September 2020, pages 5-38 to 5-45

5.5.6 Deferred gas pipeline investment

The deferred gas pipeline costs are a function of the reduction in gas usage, and the capital expenditure that can be deferred.

We have estimated the gas network benefit using the forecast capital expenditure on augmentations in the most recent revenue determinations for each gas distributor and the forecast growth in demand from new connections (noting that demand is generally decreasing from existing connections). Based on this data, we have assumed that the costs associated with growing the gas distribution network are around $15/GJ.

Consistent with the quantification of electricity network benefits, we have applied a discount factor of 70 per cent to allow for uncertainty in being able to recoup the benefits, particularly for new houses in existing suburbs.

5.5.7 Reduced GHG emissions

The avoided GHG emissions associated with the proposed changes in the NCC 2022 were calculated by:

— estimating the reduction in GHG emissions associated with the proposed changes by applying appropriate emissions intensity factors to energy savings (by source)

— estimating the costs of these emissions by applying an appropriate carbon price series.

More details about the information and assumptions used to produce these estimates are provided below.

Emissions intensity factors

Electricity

The GHG emissions from end-user use of electricity vary significantly, based upon the energy mix[196] in each jurisdiction.

DISER reports emissions factors for end users of electricity in each state and territory, including:

— Scope 2 emissions — these are indirect emissions from the generation of the electricity purchased and consumed

— Scope 3 emissions — these are indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution network.

[196] The combination of energy sources used within the electricity market.

To estimate the GHG emissions reductions for the proposed changes in NCC 2022, the CRIS used DISER's emissions projections released in late 2020 from 2022 to 2030 and then projected the change in emissions factors from 2030 onwards using information sourced from our proprietary model PowerMark. It was assumed that emissions 'flatline' after 2050.

DISER released new emissions projections in October 2021 (after the release of the CRIS).

During consultation several stakeholders questioned the emissions intensity factors used in the CRIS modelling. BlueScope Steel, in particular, noted that updated DISER emissions intensity factors for electricity have changed since the time of the modelling. In its submission, it notes that the greenhouse emissions intensity in NSW/ACT in 2030 is less than half that was assumed in the CRIS, which was drawn from late-2020 estimates. In this respect we note that the CRIS modelling was based on the DISER emissions factors available at the time. The DRIS uses DISER's newest emissions projections.

ENA argues that the CRIS does not recognise the opportunity of emissions savings from the transition to renewable gas and cites a number of projects planned or underway for hydrogen and biomethane. While we note the projects that are currently underway, we also note that there is currently significant uncertainty as to the expected pathway and timeframe for the possible transition to biogas and hydrogen. For example, the 2021 Victorian Gas Planning Report states that:

> While the transition to biogas and hydrogen is expected to play an important role in decarbonisation, they are not expected to be able to produce significant quantities of gas within the outlook period.[197]

Similarly, in its Access Arrangement for the 2021 to 2026 period, Australian Gas Networks notes the uncertainties faced by the South Australian gas distribution network – whether it transports natural gas co-mingled with hydrogen or other renewable gases, or whether it transports hydrogen or other renewable gases.[198]

Accordingly, it is difficult to speculate[199] as to the likely emissions intensity factor for gas over time for the purposes of the RIS. Furthermore, in its Gas Statement of Opportunities, the Australian Energy Market Operator's (AEMO's) central estimates do not forecast a reduction in emissions intensity. In light of this, the DRIS will use the same emissions intensity factor for gas, noting that this will overstate the benefits of any reduction in gas use. We would expect the benefits associated with reducing the emissions intensity of gas to be captured in any policy or regulatory proposals to decarbonise the gas network.

[197] AEMO 2021, *Victorian Gas Planning Report*, March; The outlook period is to 2025.

[198] Australian Gas Networks 2021, *Future of Gas, SA revised Final Plan July 2021 – June 2026*, January.

[199] It is equally difficult to model. For example, AEMO central estimates do not forecast a reduction in intensity.

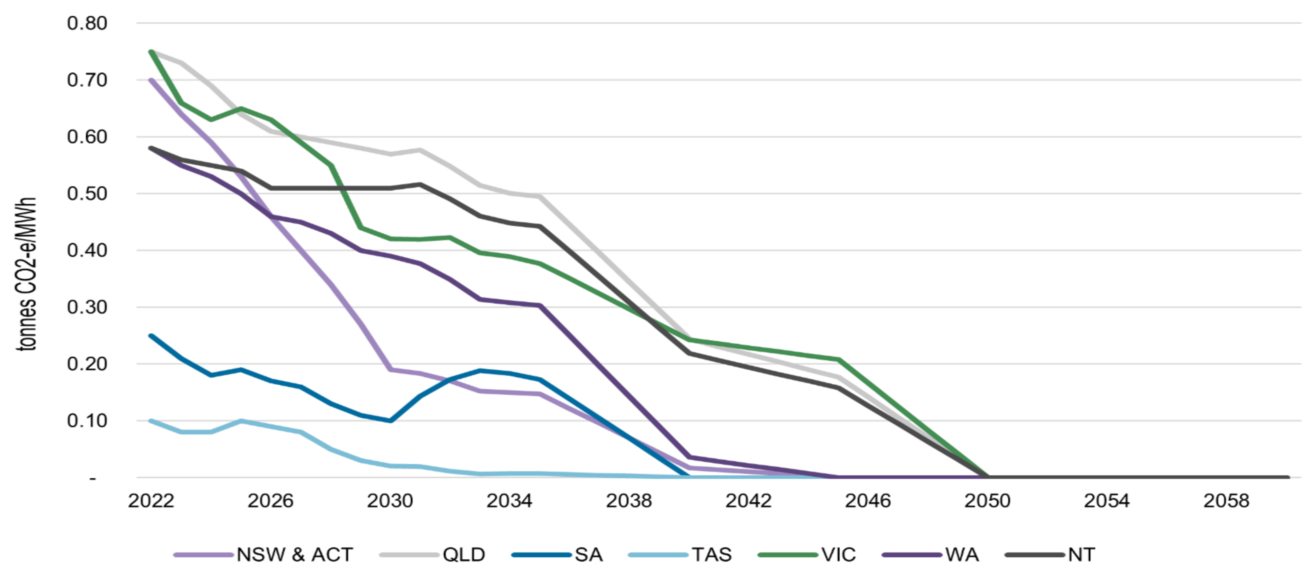
The BlueScope Steel submission also notes the unaccounted carbon cost of the underlying materials. This approach is known as life-cycle carbon emissions. For example, while solar panels ameliorate carbon emissions from grid-sourced electricity generation, they also release significant carbon emissions in their production and transportation to end use. Similarly, while HIA did not comment on the emission factors specifically, they argue that the costs of GHG emissions from the manufacturing and transport of the additional/different materials used to meet the new requirements should be added in the analysis via the use of a computational general equilibrium (CGE) model with an emissions add-on.

However, the carbon costs of industry are typically accounted for where they are incurred. The full carbon cost of the materials are considered Scope 2 (or even Scope 3) emissions[200]. That is, they are the indirect carbon cost of economic activity. Scope 2 emissions for one agent reflect the Scope 1 (direct emissions) of another agent. For example, a solar panel produced in China would be considered by their emissions, rather than those of Australia. This accounting identity guides the calculation of GHG emissions for the policy options.

An analysis of the Scope 1, Scope 2 and Scope 3 (total) emissions is called a life-cycle assessment. This type of holistic analysis is possible, but requires significantly deeper analysis of the carbon emissions of all equipment, materials, and methods used in the baseline and policy-alternative options. The study would potentially be prohibitively difficult. It also does not form the core analysis of the policy options for the purposes of the RIS.

The updated emissions factors used in the DRIS are shown in Figure 5.19.

Figure 5.19 Electricity emissions factors over time, tonnes CO2-e/MWh



Source: ACIL Allen and DISER 2021, Australia's emissions projections, October.

[200] CER, 2021, *National Greenhouse and Energy Reporting. Retrieved from Greenhouse gases and energy*, May, http://www.cleanenergyregulator.gov.au/NGER/About-the-National-Greenhouse-and-Energy-Reporting-scheme/Greenhouse-gases-and-energy

Gas

For natural gas emissions, we used the latest estimates of emissions factors for natural gas consumption reported in the National Greenhouse Accounts Factors (Scope 1 and Scope 3 metro) and assumed that:

— Tasmania's emissions are the same as Victoria's (Tasmanian gas is sourced from Victorian fields)
— the Northern Territory (NT) emissions are the same as Western Australia's (NT gas is from similar fields as WA's)
— these remain constant over time.

Table 5.24 provides details of the emissions factors used.

Table 5.24 Natural gas emissions factors, kg CO2-e/GJ

State	Scope 3[a]	Scope 1	Scope 1+3
NSW	13.10	51.4	64.50
ACT	13.10	51.4	64.50
QLD	8.80	51.4	60.20
SA	10.70	51.4	62.10
TAS [b]	4.00	51.4	55.40
VIC	4.00	51.4	55.40
WA	4.10	51.4	55.50
NT [c]	4.10	51.4	55.50

[a] Scope 3 emissions factors based on estimate for metro areas in each state. Estimates for non-metro areas vary slightly, but would not make a significant difference to the overall results.
[b] Scope 3 emissions factors were not reported for Tasmania. Figure used is based on the estimate for Victoria.
[c] Scope 3 emissions factors were not reported for the NT. Figure used is based on the estimate for WA.
Source: ACIL Allen based on DISER 2020, National Greenhouse Accounts Factors, Australian National Greenhouse Accounts, October.

Firewood

For firewood, a GHG intensity of 5 kg CO2-e /GJ was used in the modelling based on estimates prepared by George Wilkenfeld and Associates for the Commonwealth Government in relation to closed combustion type heaters (sourced from EES). This has been assumed to remain constant over time.

LPG

For LPG, we assumed a GHG intensity of 0.0642 Kg CO2-e/MJ based on estimates prepared by EES for another project in relation to the mandatory disclosure of energy ratings.[201] This has been assumed to remain constant over time.

[201] Ibid.

Carbon price

There are multiple approaches to estimate the cost of GHG emissions. Because the burden (costs) of emissions are almost entirely borne by third parties (neither the consumer, nor the electricity generator), it is an example of an economic externality. The value of GHG emissions, therefore, is not internalised in the market, which means that individuals do not make decisions based on the overall impact. This is a classic market failure, making the value of emissions difficult to estimate accurately.

Two approaches could be used to estimate the value of GHG emissions:

— The **social cost of carbon** (SCC, or sometimes rendered as SC-CO_2), which tries to estimate the marginal impact of an additional tonne of carbon based on the future costs associated with those emissions. The SCC is inherently difficult to measure, both because of the difficulty in measuring the impact of a tonne of carbon a long time in the future; and because of the assumptions around the discount rate used to evaluate those impacts. Typically, the SCC is given as a very high, high, medium, and low value — deriving from different measures of the discount rate. This is the approach most commonly taken before the advent of carbon markets, and is the approach used in the United States (and in other places throughout the world) to monetise the value of changes in GHG emissions resulting from regulatory changes. Though, given the uneven distribution of effects of climate change, the SCC *can* vary between countries if the impacts are estimated locally.

— The **resource cost of carbon**, which is based on the current cost of abatement. In the Australian context, this is the value of the spot price for fixed delivery of a tonne of carbon (e.g. Australian Carbon Credit Units – ACCU[202], or equivalent unit – price). The British and European governments have recently moved to carbon variations using the resource cost of carbon approach.

These two methods can be roughly[203] described as a demand-price and a supply-price (respectively). In a perfectly operating market — with accurate information, well-defined property rights, and rational decision making — these two prices would be identical and the carbon market would equilibrate. Both approaches introduce uncertainty and inaccuracy for different reasons. However, both approaches have been used in policy contexts and have been upheld in courts in legal contexts.

The central case analysis in this CRIS used the second approach, and DISER instructed us to use an ACCU price series to value the avoided GHG emissions. The ACCU spot price used in the CRIS was $16.55 per tonne in 2020.[204]

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[202] An ACCU is a unit issued to a person by the Clean Energy Regulator. Each ACCU issued represents one tonne of carbon dioxide equivalent (tCO2-e) stored or avoided by a project.

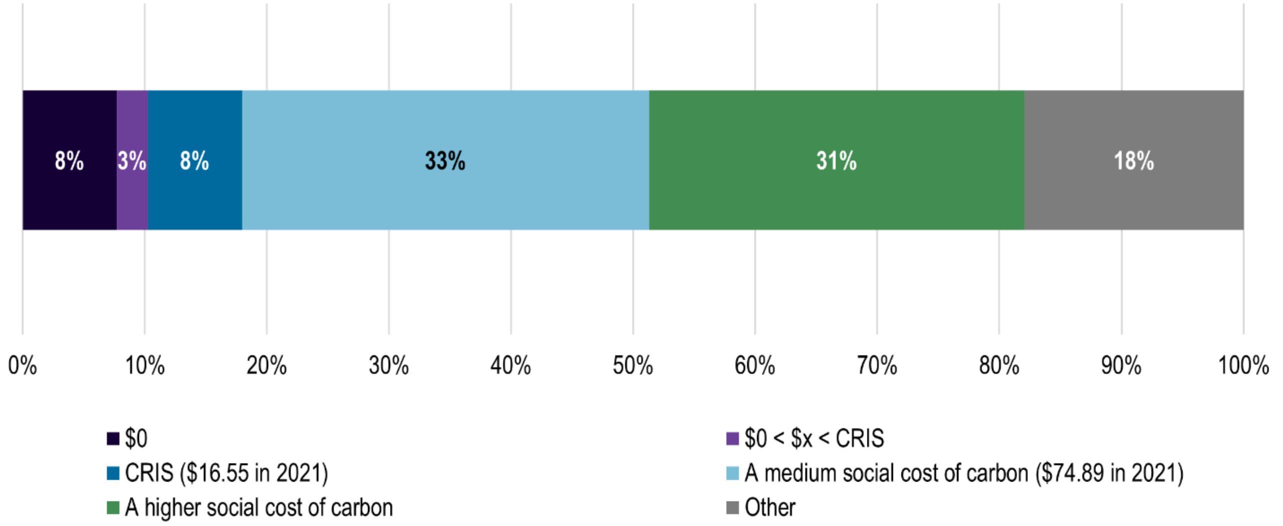
[203] Very roughly. The resource cost of carbon represents a part of a truncated supply curve, however the social cost of carbon represents an equilibrium price of a modelled hypothecated market. As noted in the text, neither is accurate for myriad reasons. The social cost of carbon is more accurately derived from the demanded abatement, and the resource cost of carbon is more accurately derived from the *current* supply costs of carbon.

[204] Clean Energy Regulator (CER) 2021, Quarterly Carbon Market Report December Quarter 2020, March, http://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/Quarterly%20Carbon%20Market%20Report%20-%20Quarter%204%20December%202020.pdf.

There was a substantial number of responses on the way that climate change is captured and accounted for in the cost-benefit analysis. Specifically, this was captured in views that the cost of carbon used in the analysis was too low, although several survey responses recommended an even lower cost of carbon than that used in the CRIS. Of those survey responses which expressed a view on the cost of carbon 64 per cent explicitly selected a higher cost of carbon than that used in the CRIS (see Table 5.19).

As shown in Table 5.19, 64 per cent of the stakeholders that responded to this question suggested the use of the social cost of carbon.

Figure 5.20 Submissions responses on the appropriate cost of carbon



Note: Responses refer to question 33, What is the most appropriate value for avoided GHG emissions (carbon price)? Chart excludes submissions that did not answer this question or were unsure, which made up the majority of respondents. 56 submissions answered this question. Of the 'Other' category, the majority argue for a very high social cost of carbon without nominating a value or measure.
Source: Citizen Space submission data.

In February 2021, the United States (US) Government's Interagency Working Group (IWG) on Social Cost of Greenhouse Gases released updated estimates of the social cost of carbon to be used when monetising the value of changes in GHG emissions resulting from regulatory changes. These estimates are based on a frequency distribution for the future costs of climate change per tonne of CO2-e based on climate modelling. The IWG's estimated social costs of carbon are presented in Table 5.25 for the following scenarios:

— The low scenario shows the average estimate[205] of the future social cost of climate change discounted using a discount rate of 5 per cent.

[205] The average cost of climate change represents the average of the costs estimated from three widely cited integrated assessment models (IAMs) in the peer-reviewed literature. These IAMs estimate global climate damages using highly aggregated representations of climate processes and the global economy combined into a single modelling framework. The three IAMs were run using a common set of input assumptions in each model for future population, economic, and GHG emissions growth, as well as equilibrium climate sensitivity – a measure of the globally averaged temperature response to increased atmospheric CO2 concentrations.

- The medium scenario shows the average estimate of the future social cost of climate change discounted using a discount rate of 3 per cent.
- The high scenario shows the average estimate of the future social cost of climate change discounted using a discount rate of 2.5 per cent.
- The high impact scenario represents higher-than-expected economic impacts from climate change further out in the tails of the social cost of carbon distribution. It uses the social cost of carbon value for the 95th percentile of the frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate.

Increasingly, countries — including the US, Canada and Germany — are adopting a social cost of carbon as the preferred price for GHG emissions. Others, such as France and the UK adopt a shadow price — which take net-zero as an absolute goal, and price the abatement costs to reach this goal — reflecting the fact that the market prices do not capture the actual costs of GHG emissions. As an example from one Australian jurisdiction, a social cost of carbon is the preferred option in the ACT. The social cost of carbon is also the recommended approach from the IPCC. It is important to note that even though there is growing support for a social cost of carbon, the inherent uncertainty means that there is a great degree of variation between estimates.

Adopting the damage cost approach means that policies which address climate change are more likely to efficiently and accurately address the impacts of climate change. Further, utilising the SCC will implicitly include the future effect of some of the previously unincorporated impacts[206] — such as the society-wide impacts of heat waves or natural disasters.[207] Recognising that market estimates are likely to underestimate the role of climate change and to address the feedback received during consultation, the DRIS modelling has been conducted using a social cost of carbon.

Broadly, the SCC quantifies impacts of changes in energy (via cooling and heating) demand; changes in agricultural and forestry output from changes in average temperature and precipitation levels and CO2 fertilization; property lost to sea level rise; coastal storms; heat-related illnesses and some diseases (e.g. malaria and dengue fever); changes in fresh water availability; some general measures of catastrophic and ecosystem impacts. However, the SCC does not account for many of the severe consequences of climate change identified by the IPCC in its latest state-of-the-climate report, the Fifth Assessment Report (AR5). Appendix E summarises the damages highlighted by the IPCC compared to what is included in the IWG SCC estimates.

Importantly, the social cost of carbon is calculated backward from future impacts. To achieve this, the social cost of carbon is inherently tied to a discount rate. Discount rates are one of the most contentious and consequential aspects of SCC estimates because the effects of climate change will be felt over many hundreds of years, whereas cutting emissions costs money now. The decision of

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[206] Broadly, the SCC quantifies impacts of changes in energy (via cooling and heating) demand; changes in agricultural and forestry output from changes in average temperature and precipitation levels and CO2 fertilization; property lost to sea level rise; coastal storms; heat-related illnesses and some diseases (e.g. malaria and dengue fever); changes in fresh water availability; some general measures of catastrophic and ecosystem impacts.

[207] It is important to note that this will include the effects at the society-wide level implicitly. It does not specifically consider the impacts for homes which are upgraded as a result of one of the policy options.

how the value today of costs and benefits in the future should be weighted is set by the OBPR by directing the use of a central discount rate of 7 discount rates in impact analyses.

While it is important that the SCC discount is as close as possible to the central discount rate used in the CBA to better align the two discount rates and minimise methodological discrepancies to the extent that is possible (and hence the social cost of carbon derived from the 5 per cent discount rate, SCC5, would be preferred), the analysis in the DRIS uses the SCC derived from the 3 per cent discount rate (SCC3)[208] for the following reasons:

— The IWG and of many economists (including prominent economists Joseph Stiglitz and Nicholas Stern[209]) and other experts suggest that the current available estimates of social cost of carbon are likely an under-estimate. Indeed, the most recent SCC estimates available from the IWG (released in February 2021) are based on impact estimates developed prior to 2017 but inflated to 2021 dollars, and as such, are considered interim values while SCC estimates are updated. The IWG intended to release a revised social cost of carbon estimate in February 2022, however at the point of writing this report these updated estimates are still not available.
— With better understanding of how climate change is affecting the world, some scientists argue that the social cost of carbon should actually start at about USD$100 to USD$200 per ton of carbon dioxide pollution, increasing to nearly USD$600 by 2100.[210]
— The majority of stakeholders who provided feedback on this issue supported the use of a medium social cost of carbon ($75 in 2021) or higher.
— Consistency with the approach used in the commercial buildings RIS in 2019, which used the medium scenario using a 3 per cent discount rate for its central estimates.

Table 5.25 Social cost of carbon estimates, 2020 – 2050 (in Australian 2021 dollars, per metric ton of CO2)

	Social cost of carbon			
Scenario	**Low**	**Medium** ***(modelled under the central case)***	**High**	**High impact**
Discount rate	**5%**	**3%**	**2.50%**	**3%**
Statistic	**Average**	**Average**	**Average**	**95th percentile**
2020	22	78	116	234
2021	24	80	118	239
2022	24	81	121	245
2023	25	83	122	249
2024	25	84	124	255
2025	27	87	127	260

[208] The SCC3 is assumed to remain constant in real terms after 2050.

[209] Nicholas Stern, Joseph E. Stiglitz 2021, *Getting the Social Cost of Carbon Right*, Project Syndicate, February, https://www.project-syndicate.org/commentary/biden-administration-climate-change-higher-carbon-price-by-nicholas-stern-and-joseph-e-stiglitz-2021-02, Accessed 6 June 2022.

[210] Hänsel, M.C., Drupp, M.A., Johansson, D.J.A. et al. Author Correction: Climate economics support for the UN climate targets. *Nat. Clim. Chang*. 11, 456 (2021). https://doi.org/10.1038/s41558-021-01021-w.

		Social cost of carbon		
2026	27	88	128	265
2027	28	90	130	270
2028	28	91	131	276
2029	29	93	134	282
2030	31	94	136	286
2031	31	96	139	292
2032	32	97	140	298
2033	32	99	142	304
2034	34	102	145	310
2035	34	103	146	314
2036	35	105	147	320
2037	37	106	150	326
2038	37	108	152	332
2039	38	109	153	336
2040	38	111	156	342
2041	40	114	158	347
2042	41	115	159	352
2043	41	116	162	357
2044	43	118	164	363
2045	44	119	165	367
2046	44	121	168	373
2047	46	124	170	378
2048	47	125	171	383
2049	22	78	116	234
2050	24	80	118	239

Note: figures have been rounded.

Source: Interagency Working Group on Social Cost of Greenhouse Gases, United States Government 2021, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990, February.

5.5.8 Health benefits

Benefits from improved air quality

The mining and combustion of coal for electricity generation in Australia produces air pollution containing particulate matter, nitrogen oxides, sulphur dioxide, as well as other emissions. These can cause health problems such as respiratory illness and can also affect local economies.

Particulate matter, sulphur dioxide and nitrogen oxides are the main power station emissions contributing to health damage costs. These emissions are associated with respiratory and cardiac diseases.

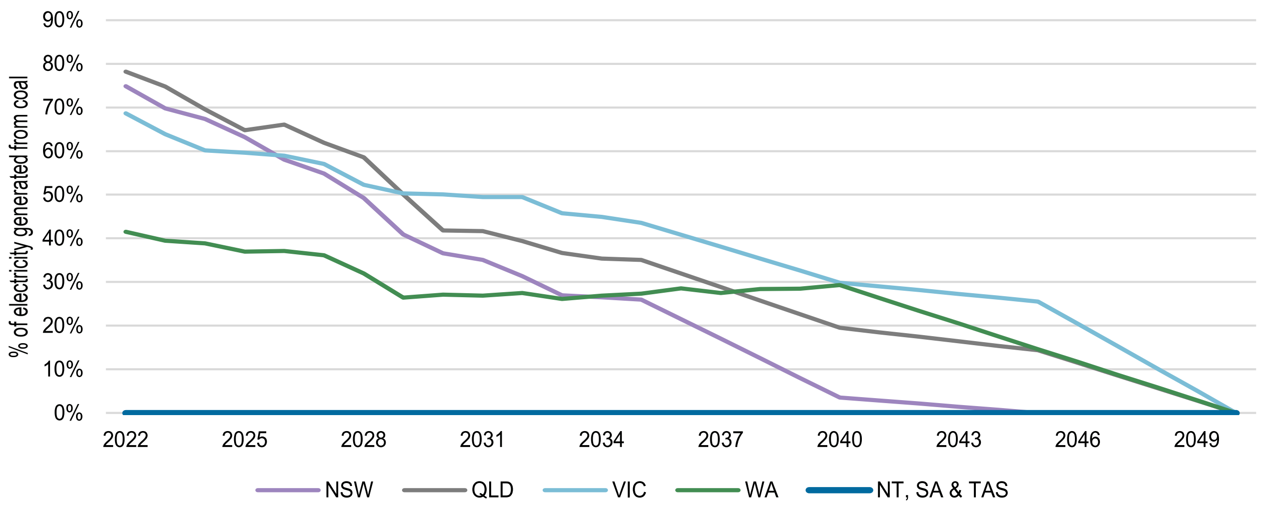
The estimate of the economic impact associated with the health damage costs from these emissions is based on estimates of health benefits produced by Mazaheri et al. (2021).[211] In this report, the authors estimated health damage costs of coal-powered electricity generation of AUD$2.40 per MWh of total energy generation.[212]

As the estimates in this study were in 2016 dollars, the $2.40 per MWh figure was converted into 2021 dollars using inflation rate estimates from the ABS. This produces a 2021 figure of $2.58 per MWh (being for NSW, this figure relates to electricity generated from black coal). For this analysis it was assumed that:

- the health benefits from reductions in electricity generated from brown coal (only relevant to Victoria) are the same as those from reductions in electricity generated from black coal
- this estimate applies to all other states producing electricity generated using black coal.

This figure was then multiplied by the difference in the electricity generated from coal in each state and territory over time as a result of the proposed changes in NCC 2022 (sourced from our proprietary model *PowerMark*, see percentage of coal generated in Figure 5.21[213]) for Option A. The results for Option B were derived by scaling the results from the *PowerMark* modelling appropriately based on the electricity savings between the Options.

Figure 5.21 Percentage of electricity generated from coal



Source: ACIL Allen

[211] Mazaheri, M.; Scorgie, Y.; Broome, R.A.; Morgan, G.G.; Jalaludin, B.; Riley, M.L. 2021, *Monetising Air Pollution Benefits of Clean Energy Requires Locally Specific Information*. Energies 2021, 14, 7622. https://doi.org/10.3390/en14227622

[212] This estimate represents the health cost reductions per MWh reduction in total energy generation due to energy demand reduction and are based on the life years gained approach for the medium demand shock scenario and the 2026–2118 period (excluding ramp up), and assuming a 7 per cent discount rate.

[213] It is assumed that the percentage of electricity generated from coal in most states after 2050 is zero.

In addition to health benefits from reduced pollution from coal generated electricity, we used estimates from the Australian Academy of Technological Sciences and Engineering (ATSE) report on the Hidden Costs of Electricity Generation[214] on the health costs associated with emissions from Australian combined cycle gas power stations ($0.74 per MWh in 2009 dollars) to estimate the health benefits from reductions in gas-generated electricity.[215] In 2021 dollars this figure is $0.93 per MWh. This figure was then multiplied by the difference in the electricity generated from gas in each jurisdiction over time as a result of the proposed changes to the NCC (sourced from our proprietary model *PowerMark* and derived for Option B as described above).

Benefits from reductions in gas use

The health impacts of gas consumption are highly related to the manner in which it is burnt. A recent Climate Council report illustrates how different fluing technology can change the ultimate impacts of domestic gas burning (see Figure 5.22). Negative health impacts accrue from a combination of particulate matter and noxious gasses released in their burning.

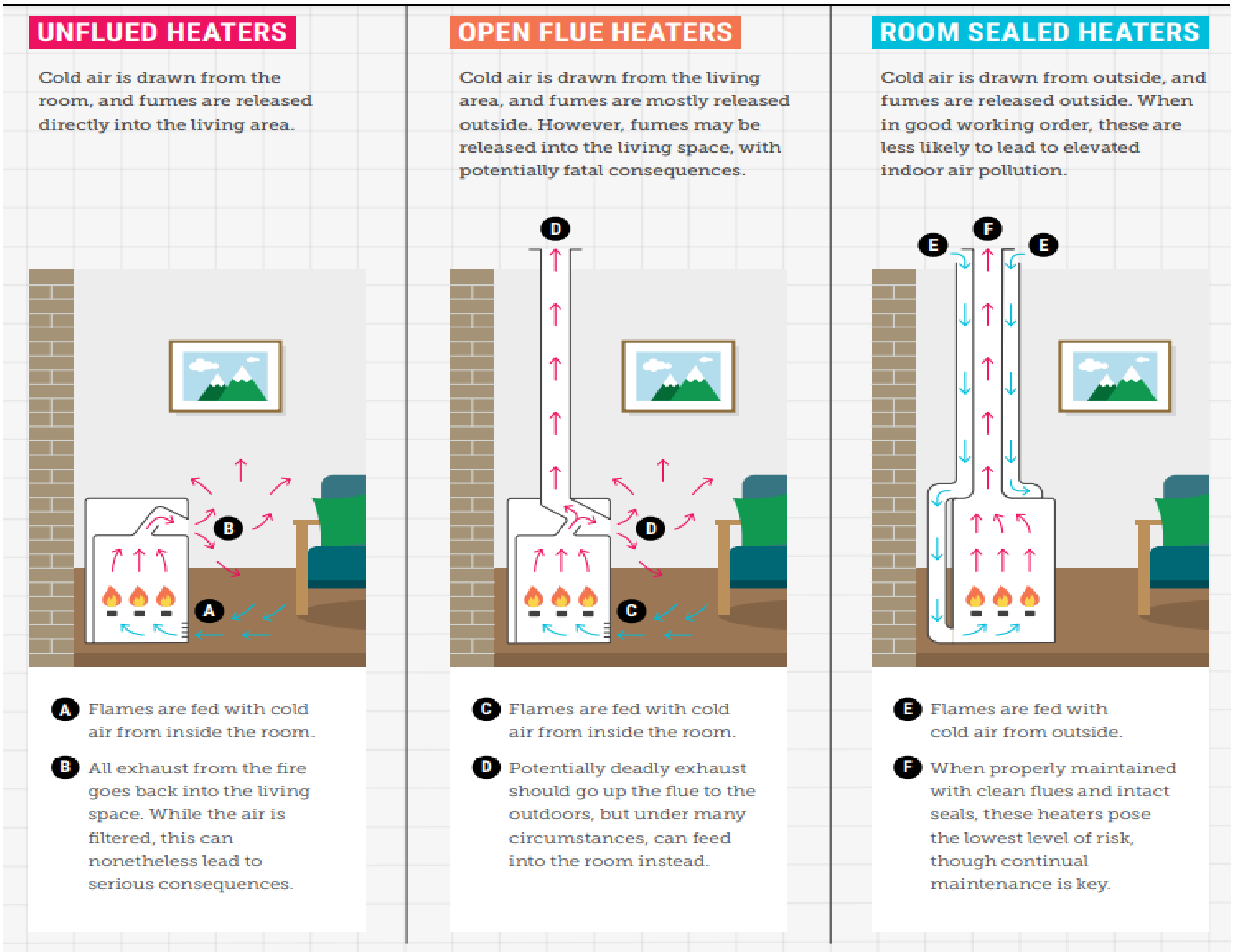
The health impacts from domestic gas burning are therefore equal to or greater than the health impacts of gas burning at gas-fuelled power-stations which tend to be at some distance to residential houses. For this lower-bound estimate of the health impacts of reductions in domestic gas use, we have used the ATSE estimates referred above on the health costs associated with emissions from Australian combined cycle gas power stations ($0.93 per MWh in 2021 dollars).[216]

[214] ATSE 2009, *The Hidden Costs of Electricity: Externalities of Power Generation in Australia*, https://www.atse.org.au/wp-content/uploads/2019/01/the-hidden-costs-of-electricity.pdf, accessed 4 March 2021.

[215] While ATSE's estimates relate to combined cycle gas power stations, using natural gas (whether to generate electricity or for other purposes) emits NOx and PM10 particulates and a lower level of SOx and hence it was considered that ATSE's estimates could be used as proxy for the health damage costs of natural gas use on an equivalent per PJ basis.

[216] While ATSE's estimates relate to combined cycle gas power stations, using natural gas (whether to generate electricity or for other purposes) emits NOx and PM_{10} particulates and a lower level of SOx and hence it was considered that ATSE's estimates could be used as proxy for the health damage costs of natural gas use on an equivalent per PJ basis.

Figure 5.22 Gas emissions fluing and health impacts



Source: Bambrick, H., Charlesworth, K., Bradshaw, S., & Baxter, S., 2021, Kicking the gas habit: How gas is harming our health. Canberra: Climate Council.

Benefits from reductions in wood use

The CRIS did not include estimates of the health benefits associated with reductions in wood use. A submission from the New England Greens provided during consultation noted that there are significant benefits from reduced air pollution from woodsmoke. Two references about the health costs per wood heater were provided. In response to this feedback, a methodology to estimate the impacts of reduction in wood use was developed for the DRIS.

Firewood burners are a significant cause of particulate matter and noxious gases. Firewood burners are far less common in new builds than gas heaters. However, they are likely to have a larger effect on human health than gas burners — particularly for poorly maintained wood burners.

The health impacts of reduced firewood usage have been calculated as a per megajoule dollar value based on the particulates emitted by burning firewood and the health costs associated with those particulates.

Health costs associated with particulates

Several studies have analysed the health costs from particulate emissions in Australia. Most recently, Robinson et. al.[217] estimated that particulate pollution from wood heaters in Armidale caused 210 lost years of life (14 excess deaths) per year — equivalent to $10,930 per heater per year. This highlights the potentially high costs of woodfires in colder climates where they are relatively more common[218].

The health effects of PM_{10} — a common deleterious particulate released from firewood — have been studied in the Australian context by Denison et al.[219] who found:

- increases in total, respiratory, and cardiac mortality
- increased hospital, surgery and casualty admissions for respiratory disease, bronchitis, asthma, cardiovascular disease and chronic obstructive pulmonary disease
- increased limitations to functional activity, either as absence from school (children) or work loss days and other restrictions for adults
- increased in the daily numbers of respiratory symptoms
- pulmonary function decreases in healthy children or adults with obstructive airways problems.

Most Australian studies either estimate a per heater cost or a per tonne of PM_{10} (or of volatile organic compounds (VOCs) — both identified as causes of health impacts from woodfired heating). Typically, health impacts from vehicle emissions (sometimes from plant emissions) are used in these studies, given the relatively larger focus.

A selection of studies which estimate the health impacts of these types of particulates are shown in Table 5.26.

Table 5.26 Range of estimates of health costs associated with particulate emissions

Study	Estimate type	PM_{10} (2021$/tonne)
BDA Economics (2006)[220] *Wood heater Particle Emissions and Operating Efficiency Standards: Cost-benefit Analysis*	Sydney	$250,158
	Port Phillip	$240,355
	Southeast Queensland	$80,748
	Perth	$150,254
	Canberra	$153,319
	Launceston	$153,319

[217] Robinson, D. L., Horsley, J. A., Johnston, F. H., & Morgan, G. G. 2021, *The effects on mortality and the associated financial costs of wood heater pollution in a regional Australian city*, Medical Journal of Australia, 215(6), 269-272.

[218] Romanach, L., & Frederiks, E. 2020, *Residential Firewood Consumption in Australia*, CSIRO.

[219] Denison, L., Simpson, R., Petroeschevsky, A., Thalib, L., & Williams, G. 2000, *Effects of ambient particle pollution on daily mortality in Melbourne, 1991–1996*, Journal of Exposure Science & Environmental Epidemiology, 488-496.

[220] BDA Economics 2006, *Wood heater Particle Emissions and Operating Efficiency Standards: Cost-benefit Analysis*, Department of the Environment and Heritage.

Study	Estimate type	PM_{10} (2021$/tonne)
AECOM (2011)[221] *Economic Appraisal of Wood Smoke Control Measures*	Weighted average (NSW)	$108,654
Beer (2002)[222] *Valuation of pollutants emitted by road transport into the Australian atmosphere*	Upper bound	$510,204
	Best estimate	$340,136
	Lower bound	$249,910
DIT (2010)[223] *Final Regulation Impact Statement for Review of EURO 5/6 Light Vehicle Emissions Standards*	Capital cities	$533,441
	Other urban areas	$145,488
	Non-urban areas	$1,936

Source: ACIL Allen and noted.
Note: Values updated to December 2021 based on Health Consumer Price Index (CPI) from the ABS.

The range of health costs in Table 5.26 illustrates the degree of uncertainty regarding overall health costs, as well as the importance of local population density and climatic conditions. For the DRIS, we have used the median value from the estimates in Table 5.26 of approximately $150,000 per tonne of PM_{10}. Given the range of uncertainty, we will mark the benefits of avoided health costs due to reductions in wood consumption as *uncertain*.

Particulates emitted by burning firewood

We will use an emissions factor of 50 mg of PM_{10} per MJ burnt of firewood based on Haluza[224]. We acknowledge that there is a range of factors which drive this emissions factor, including[225]:

— ambient air quality
— type of firewood used
— firewood condition, and
— efficiency of the heater.

Health costs associated with burning firewood

As a result, we have assumed that the avoided health impact per megajoule of firewood burnt is $0.00750 (in 2021 dollars).

221 AECOM 2011, *Economic Appraisal of Wood Smoke Control Measures*, NSW Office of Environment and Heritage.

222 Beer, T. 2002, *Valuation of pollutants emitted by road transport into the Australian atmosphere*, 16th International Clean Air & Environment Conference. Christchurch: CSIRO Atmospheric Research.

223 Department of Infrastructure and Transport (DIT) 2010, *Final Regulation Impact Statement for Review of EURO 5/6 Light Vehicle Emissions Standards*, Department of Infrastructure and Transport.

224 Haluza, D., Kaiser, A., Moshhammer, H., Flandorfer, C., Kundi, M., & Neuberger, M. 2012, *Estimated health impact of a shift from light fuel to residential*, Journal of Exposure Science and Environmental Epidemiology, 339-343.

225 Denier van der Gon, H., Bergstrom, R., Fountoukis, C., Johansson, C., Pandis, S., Simpson, D., & Visschedijik, A. 2015, *Particulate emissions from residential wood combustion in Europe - revised estimates and an evaluation*, Atmospheric Chemistry and Physics, 6503-6519.

6 Economy-wide analysis: dwelling level impacts

This chapter summarises the **impacts of the proposed changes to the NCC on a sample of composite dwellings from a societal perspective** (i.e. measured using wholesale energy prices as a proxy for avoided resource costs). Notably, **these impacts are different to those experienced by individual households** (which are assessed in Chapter 8).

As noted in Chapter 5, costs and benefits have been calculated using expected compliance pathways for different dwelling types. These compliance pathways reflect the assumed likely market response of a new dwelling under the proposed policy settings as modelled by EES.

6.1 Dwelling costs

The proposed changes to the NCC would require households to invest in additional energy efficiency measures. The nature of the required investments has been assessed by TIC and EES. Using their estimates as a basis, we:

— calculated the marginal costs of compliance with NCC 2022 under each of the upgrade pathways outlined in Section 5.3.6, for each of the climate zones and jurisdictions modelled by EES (details of these are provided in Appendix F)

— constructed a 'composite' dwelling for each of the climate zones and jurisdictions modelled by EES that accounts for the number of dwellings that would take each of the described upgrade pathways. These estimates are presented in Table 6.1 to Table 6.4.

The estimates presented in these tables include:

— all costs incurred at the time of construction (but exclude the costs to replace the PV inverters after ten years and the additional costs incurred by difficult blocks, which are included the Australia-wide results outlined in the next chapter)

— the estimated reductions in the costs of space conditioning equipment as a result of the improved thermal shell. These reductions are treated as cost offsets and, as noted in Chapter 5, are only incurred by dwellings that are rated 6 stars in the BAU

— the estimated costs of mitigating thermal bridging in steel frame buildings.

These estimates reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland (see Box 6.1).

Box 6.1 Energy performance benchmark for Class 2 dwellings in Queensland

As outlined in Section 4.2.2, the annual energy use budget underpinning the proposed policy options was set based on a ‘benchmark home’ built with the following characteristics:

— building shell performance level: equivalent to a 7 star NatHERS rated dwelling
— heating equipment: equivalent to a 4.5 star rated GEMS 2012 heat pump heater
— cooling equipment: equivalent to a 4.5 star rated GEMS 2012 heat pump cooler
— water heater: instantaneous gas
— 4 Watts per square metre of lighting.

As part of the adjustments of the technical modelling for the DRIS, the water heater benchmark for Class 2 dwellings in Queensland was changed from gas instantaneous to heat pump. The economic modelling of Option A and Option B in the DRIS reflects this change (i.e. the modelling results for these options reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions). Additional information about this change is provided in TIC’s companion technical documentation.[226]

Further development of the options resulted in the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater. Due to time constraints, the economic modelling of Option A and Option B was not updated to reflect this change. However, additional economic modelling was undertaken to assess the impacts of resetting the benchmark in the Combined Option (Option A for Class 1 and Option B for Class) to reflect a nationally consistent approach. Given this, the economy-wide modelling results presented in the DRIS:

— for Option A and Option B overall reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions
— for the Combination Option reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater.

Notably, resetting the benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater has a small overall effect on the national results. Indicatively, this change would decrease the net costs for Class 2 dwellings Australia-wide under Option B by around $10 million and decrease the national BCR of the Combined Option by around 3 per cent (to 0.78).

Source: ACIL Allen.

Costs incurred vary substantially between jurisdictions and climate zones. For example, the estimated additional costs associated with a Class 1 dwelling in Climate Zone (CZ) 1 in the Northern Territory under Option A are $7,138 (mainly driven by the costs of solar PV panels), while the estimated additional costs for a Class 1 dwelling in CZ2 in Queensland are marginal, at only $723. Under Option B, the highest estimated cost increase in Class 1 dwellings would be experienced in CZ8 in NSW (at $3,469), and the lowest estimated cost increase would be experienced by dwellings in CZ1 in Queensland (at $153). Under Option B, Class 1 dwellings in CZ3 in Queensland are expected to experience a small saving in construction costs.

The estimated costs of compliance for apartments are on average higher than for Class 1 dwellings across both policy options. The lowest estimated cost to comply for a Class 2 dwelling is $2,493 for a unit in Tasmania under Option A, and $285 for a unit in NSW CZ4 under Option B. The highest estimated cost of compliance for a Class 2 dwelling is $4,073 in CZ7 in Victoria under Option A, and $2,683 in CZ5 in Western Australia.

For all dwellings, the additional estimated costs of complying with Option B are lower than the costs of complying with Option A.

Table 6.1 Estimated marginal construction costs for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option A, $/dwelling in 2022 ($2021)

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)[b]	Total
NSW	2	650	1,704	-165	37	-128	2,097
NSW	4	362	2,646	-193	52	-133	2,733
NSW	5	1,227	2,687	-195	53	-134	3,639
NSW	6	213	3,255	-204	57	-135	3,187
NSW	7	677	2,665	-185	89	-127	3,118
NSW	8	497	4,522	-191	54	-146	4,736
VIC	4	1,207	1,839	-752	170	-344	2,120
VIC	6	1,014	2,221	-417	37	-354	2,500
VIC	7	1,597	2,220	-418	37	-355	3,081
VIC	8	1,067	4,213	-642	0	-366	4,272
QLD	1	287	52	-86	900	-95	1,058
QLD	2	496	52	-101	386	-111	723
QLD	3	174	52	-114	900	-125	888
QLD	5	951	52	-114	906	-125	1,671
SA	4	1,111	986	-479	351	-224	1,745
SA	5	1,067	986	-473	167	-218	1,529
SA	6	889	1,826	-470	142	-229	2,159
WA	1	357	784	-498	237	-84	795
WA	3	459	784	-548	237	-139	793
WA	4	954	459	-543	196	-135	931
WA	5	872	459	-555	196	-149	823
WA	6	820	842	-546	193	-150	1,160
TAS	7	1,363	1,112	-186	729	-177	2,840

[226] TIC 2022, *ABCB NCC 2022 – Energy Efficiency Provisions DRIS Update – Companion Technical Documentation*.

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)[b]	Total
NT	1	1,359	5,948	-59	1	-111	7,138
NT	3	1,273	1,493	-99	243	-132	2,778
ACT	7	214	717	-124	404	-158	1,054

[a] Includes the cost of solar PV panels and inverter (for the first year only). As noted in Chapter 5, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

[b] Plant savings refer to reductions in the costs of space conditioning equipment due to the improved thermal shell.

Note: Negative numbers reflect savings in construction costs. Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.2 Estimated marginal construction costs for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option B, $/dwelling in 2022 ($2021)

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)[b]	Total
NSW	2	650	313	-122	17	-128	730
NSW	4	362	495	-132	24	-133	616
NSW	5	1,227	503	-132	25	-134	1,489
NSW	6	213	579	-135	28	-135	550
NSW	7	677	518	-126	25	-127	967
NSW	8	497	3,205	-145	58	-146	3,469
VIC	4	1,207	198	-535	478	-344	1,003
VIC	6	1,014	517	-440	383	-354	1,121
VIC	7	1,597	199	-441	494	-355	1,494
VIC	8	1,067	938	-90	338	-366	1,886
QLD	1	287	8	-52	4	-95	153
QLD	2	496	11	-99	2	-111	298
QLD	3	174	8	-113	1	-125	-54
QLD	5	951	12	-112	2	-125	727
SA	4	1,111	57	-396	55	-224	602
SA	5	1,067	57	-391	55	-218	569
SA	6	889	91	-397	65	-229	420
WA	1	357	46	-205	168	-84	282
WA	3	459	46	-254	168	-139	280
WA	4	954	76	-517	136	-135	514

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)[b]	Total
WA	5	872	76	-529	136	-149	406
WA	6	820	427	-524	183	-150	755
TAS	7	1,363	130	-161	217	-177	1,371
NT	1	1,359	1,231	-66	128	-111	2,541
NT	3	1,273	1	-99	124	-132	1,167
ACT	7	214	74	-26	186	-158	290

[a] Includes the cost of solar PV panels and inverter (for the first year only). As noted in Chapter 5, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

[b] Plant savings refer to reductions in the costs of space conditioning equipment due to the improved thermal shell.

Note: Negative numbers reflect savings in construction costs. Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.3 Estimated marginal construction costs for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option A, $/dwelling in 2022 ($2021)

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)[a]	Total
NSW	2	423	2,276	1,796	-109	4,385
NSW	4	205	2,321	1,781	-85	4,222
NSW	5	531	2,279	1,804	-114	4,500
NSW	6	336	2,223	1,889	-101	4,347
NSW	7	873	2,202	1,925	-124	4,875
VIC	6	289	2,889	1,686	-101	4,763
VIC	7	560	2,887	1,697	-93	5,051
QLD	1	140	3,281	1,729	-57	5,093
QLD	2	413	2,893	1,827	-80	5,053
QLD	5	562	2,676	1,933	-90	5,081
SA	5	472	1,446	1,883	-104	3,696
WA	5	266	1,051	1,962	-61	3,218
TAS	7	184	454	1,923	-68	2,493
NT	1	140	3,454	1,252	-46	4,800
ACT	7	329	1,156	1,740	-52	3,173

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)[a]	Total

[a] Plant savings refer to reductions in the costs of space conditioning equipment due to the improved thermal shell.

Note: Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.4 Estimated marginal construction costs for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option B, $/dwelling in 2022 ($2021)

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)[a]	Total
NSW	2	423	-39	146	-99	431
NSW	4	205	16	141	-77	285
NSW	5	531	-27	152	-102	554
NSW	6	336	0	146	-91	392
NSW	7	873	-7	162	-112	917
VIC	6	289	176	143	-91	518
VIC	7	560	222	117	-83	815
QLD[b]	1	140	197	1,763	-51	2,048
QLD[b]	2	413	-1	1,809	-72	2,148
QLD[b]	5	562	9	1,827	-81	2,318
SA	5	472	-147	419	-94	650
WA	5	266	-276	384	-55	319
TAS	7	184	-45	1,164	-62	1,241
NT	1	140	-38	1,525	-41	1,586
ACT	7	329	66	578	-47	926

[a] Plant savings refer to reductions in the costs of space conditioning equipment due to the improved thermal shell.

[b] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Resetting the benchmark to gas instantaneous for Class 2 dwellings in Queensland under Option B would reduce the total costs for apartments in Queensland CZ1 to $582, CZ2 to $855 and CZ5 to $1,005.

Note: Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

6.1.1 Case studies

This section outlines three case studies showing the impacts of alternative design choices on the costs of upgrading the building fabric to 7 stars.

Case study 1: a large dwelling

As mentioned in Section 5.4.1, while TIC's estimated costs and benefits for the building fabric upgrade appropriately represent the impacts of the requirements on the *average* homes currently being built, the approach might not appropriately reflect the costs of a *marginal* home which has specific characteristics (e.g. larger floor areas, inflexible design due to consumer preferences, small/narrow blocks, etc.) that may result in increased/decreased costs/benefits. To understand the impacts of the proposed requirements in these marginal homes, TIC assessed a sample of dwellings provided by industry during consultation.

Two houses in this sample which were much larger than the average size shown in the CSIRO portal (submitted by Builder A) were re-rated by TIC. The houses were based in Melbourne (Tullamarine) and the dwelling orientation selected for re-rating was chosen to represent the worst case (i.e. the most expensive to upgrade). In addition, to compare the approach taken in the RIS with the 7 star upgrade cost evaluation provided by Builder A:

- the upgrades used by Builder A to achieve 7 stars were costed using the CRIS unit costs
- each house was upgraded to 7 stars using the suite of improvement strategies employed during the CRIS assessment.

Table 6.5 summarises TIC's findings from this analysis. Costs are reported for the two dwellings most similar to the two Builder A houses. The average and range of costs found across the sample of dwellings in Melbourne are also shown.

As shown in Table 6.5, the 7 star upgrade solutions developed by Builder A's assessor resulted in much higher costs than assumed in the CRIS (which assumed \$12/m^2) \$18/m^2 and \$37/m^2 for the two designs. To some extent, this is in line with the CRIS because:

- these dwellings were assessed on their worst orientation while the CRIS dwellings were oriented on one of the worst orientations
- the NatHERS area correction effectively requires a higher level of energy efficiency for very large houses (more than 2.5 times the average from the portal) like House 1. The large house modelled for the CRIS (SBH01) also showed higher upgrade costs than the average due to the impact of the area correction.

By contrast, the CRIS focuses on the central case. That some dwelling sizes and orientations have higher costs than the central case is to be expected.

Detailed examination of the methods used to obtain 7 stars by Builder A showed several opportunities to reduce these upgrade costs, such as:

- more nuanced use of double glazing (e.g. using higher performance glazing and focussing on rooms with the highest heating loads)
- selected trimming of window sizes for the larger windows (4 to 8 per cent in the larger house, not needed in the smaller house)

— a more nuanced approach to the use of ceiling fan (e.g. using multiple large diameter fans only in the room(s) with the highest cooling loads).

When assessed with these upgrade techniques – as applied in the RIS analysis – costs are significantly reduced and fall within the range of dwellings assessed in the RIS for Melbourne. This finding suggests that the industry will need time to develop their skills in achieving 7 stars cost-effectively, and more CPD will be required for designers and NatHERS assessors to assist them with this task.

Additional details of TIC's analysis can be found in their report *'A review of industry feedback and approaches to upgrading to 7-star building fabric'.*

Table 6.5 Evaluation of 6 to 7 star upgrade for Builder A houses

Dwelling	Upgrade Cost	Net Conditioned Floor Area	$ / m^2
Average from RIS	$2,058 ($700-$3,800)	167.8	$11.65 ($4.50-$22.00)
SBH01 (largest house from the CRIS)	$3,782	257.6	$13.51
House 1: 7 stars by Builder A	$10,349	386.0	$23.63
House 1: 7 stars using RIS techniques	$7,897	386.0	$18.03
House 1: 7 stars using RIS windows	$4,257	386.0	$9.72
SBH05 (house which closely matched the size of House 2)	$1,468	145.9	$10.06
House 2: 7 stars by Builder A	$7,180	145.9	$37.05
House 2: 7 stars using RIS techniques	$3,251	145.9	$16.77
House 2: 7 stars using RIS windows	$1,999	145.9	$10.32

Source: TIC 2022, *A review of industry feedback and approaches to upgrading to 7-star building fabric*, May.

Case study 2: a passively designed house

TIC assessed a sample of specialist passive solar and well-ventilated designs which were designed to suit specific climates. The specialist designs showed significantly lower costs to achieve 7 stars than poorly oriented volume builder dwellings (see Table 6.6). The costs for specialist designs were generally in the range of 13-61 per cent lower per square meter than the costs for an average volume built house.

Importantly, the extent to which cost savings can be achieved through more climatically-appropriate design is not the same in every case. In cooler climates, or for lots with overshadowing to the north of buildings, or where the lot shape does not facilitate orienting living areas to the north, the extent of cost savings from more climatically-appropriate design are limited.

Table 6.6 Comparison of costs of improving building fabric from 6 to 7 stars in volume built and specialist designs

	Average volume built house	Specialist designs	Difference in cost
	Cost ($/m2)	**Cost ($/m2)**	**%**
Darwin	$11.42	$4.45	-61%
Longreach	$8.76	$3.65	-58%
Brisbane	$4.95	$2.22	-55%
Perth	$6.53	$5.31	-19%
Adelaide	$11.41	$4.80	-58%
Canberra	$15.30	$9.54	-38%
Hobart	$11.66	$6.81	-42%
Mildura	$9.88	$5.41	-45%
West Sydney	$10.29	$8.14	-21%
Cairns	$4.71	$3.04	-35%
Tullamarine	$11.86	$10.30	-13%
Thredbo	$10.55	$6.81	-35%

Source: TIC.

Case study 3: impact of keeping the window size unchanged

As discussed in Section 5.4.1, to meet the proposed thermal requirements in NCC 2022 at the lowest cost of compliance, TIC's modelling of the costs of improving building fabric from 6 to 7 stars assumes a reduction in window size. However, the impacts of these reductions on amenity or dwelling value were not quantified by TIC or the CRIS.

Several submissions provided during consultation argue that:

— the window area reduction used at 7 stars underestimates the costs of meeting the proposed shell requirements

— the loss in amenity due to smaller windows should be valued. AGWA and HIA provided references to research that highlight the potential negative impacts of reductions in window size and daylight. While these references do not provide sufficient evidence to value the amenity losses from reductions in window size, they provide rich evidence about the importance of daylight and windows. A discussion of the benefits of window and glazing based on the references is provided in Appendix I.

In response to feedback from stakeholders, TIC undertook an analysis of the costs to achieve 7 stars if the window area used to obtain 6 stars remained the same for each of the typical houses used in the modelling for the CRIS (SBH01 to SBH06). This analysis shows that, if window size had been maintained as per the 6 star window area average, the cost would have been between 13 per cent (in Hobart) and 58 per cent (in Thredbo) higher (see Table 6.7). This increase represents an additional cost per square metre of between $0.90 (in Cairns) and $6.68 (in Thredbo). While these costs are small, they are significant in aggregate. TIC notes that:

> Given the price sensitivity of the housing market, it is likely that builders/designers would ultimately pursue some level of window trimming to contain costs in poorly oriented houses like those modelled in the RIS.[227]

Table 6.7 Impacts of maintaining 6-star window sizes at 7-stars

Climate	CRIS original $ / m^2	CRIS % reduction in window area	Increase with no window reduction $/m^2	% increase with no window reduction
Darwin	$11.42	6.9%	$1.85	16%
Longreach	$8.76	2.2%	$1.29	15%
Brisbane	$3.50	2.4%	$1.15	33%
Perth	$6.53	8.0%	ab$1.75	27%
Adelaide	$11.41	6.5%	$3.43	30%
Canberra	$15.30	7.6%	$3.69	24%
Hobart	$11.66	4.4%	$1.50	13%
Mildura	$9.88	5.4%	$3.27	33%
West Sydney	$8.51	4.8%	$2.21	26%
Cairns	$4.71	5.0%	$0.90	19%
Tullamarine	$8.46	5.4%	$2.39	28%
Thredbo	$11.52	9.0%	$6.68	58%

Source: TIC 2022, *A review of industry feedback and approaches to upgrading to 7-star building fabric*, May.

Notably, although the archetypes used for the RIS modelling were subject to window area reductions, this does not mean that all dwellings will need to reduce window areas to achieve 7 stars or face higher costs if they do not. The climatically adapted dwellings case study examples discussed above suggest dwelling designs with ideal window orientation used 50 per cent higher window areas and cost between 20 per cent and 60 per cent less to meet a 7 star building fabric standard. Improved design practices to increase the area of well-oriented windows, therefore, offers significantly greater design freedom and lower costs.

[227] TIC 2022, *A review of industry feedback and approaches to upgrading to 7-star building fabric*, May.

6.2 Dwelling benefits

As outlined in the previous chapter, households will benefit from the proposed changes in the NCC 2022 through:

— reduced energy consumption
— reductions in the costs of space conditioning equipment due to the improved thermal shell.[228]

For those households with both electricity and gas connections, the reduced energy consumption may reflect either a decrease in both electricity and gas consumption, or a decrease in one at the expense of another.

As noted in Chapter 5, modelling data on a dwelling's energy consumption under the new proposed policy settings was provided by EES. Similar to the compliance costs outlined above, using EES's estimates as a basis, we:

1. Calculated the marginal changes in energy consumption associated with the NCC 2022 under each of the upgrade pathways outlined in Section 5.3.6 for each of the climate zones and jurisdictions modelled by EES (details of these are provided in Appendix G). These estimates capture changes in energy consumption across all end uses within the dwelling including:
   – heating
   – cooling
   – water heating
   – lighting
   – swimming pool pumps and spa pumps (where relevant to the case study)
   – 'other' loads (which include cooking, plug loads and standby power).
2. Constructed a 'composite' dwelling for each of the climate zones and jurisdictions modelled by EES that accounts for the number of dwellings that would take each of the described upgrade pathways. These estimates are presented in Table 6.8 to Table 6.11.

As shown in these tables, the proposed policy settings are estimated to result in:

— overall reductions in the use of:
   – electricity and gas in Class 1 dwellings under both Option A and Option B, except for dwellings in CZ8 in Victoria under Option B for which electricity use increases, but gas use decreases significantly
   – LPG and firewood in Class 1 dwellings both under Option A and Option B
   – electricity and gas in Class 2 dwellings under Option B

[228] These are captured in the individual dwelling costs outlined in the previous section as cost offsets.

   - electricity and gas in Class 2 dwellings under Option A, except for dwellings in Victoria CZ6 and in Western Australia that are estimated to experience and overall increase in electricity over the period of analysis. [229]
- a switch from gas to electricity for Class 1 dwellings in CZ8 in Victoria under Option B and for Class 2 dwellings in various jurisdictions under Option A, which results in increased electricity consumption and decreased gas consumption
- generally, larger reductions in energy consumed in Class 2 dwellings than in Class 1 dwellings in the same jurisdictions/climate zone under both options for most jurisdictions/climate zone
- larger reductions in total energy consumption for most Class 1 dwellings (except dwellings in Victoria CZ8) and all Class 2 dwellings under Option A, than under Option B.

As discussed in Chapter 5, energy savings resulting from the proposed changes are locked in for the life of the installed measures. The estimated value of these savings in Present Value Terms (PVa) using a central discount rate of 7 per cent is provided in Table 6.12 to Table 6.15. These values have been calculated using the data in Table 6.8 to Table 6.11 and the estimates of wholesale energy prices outlined in the previous chapters.

Depending on the location and nature of the dwelling, it is estimated that the proposed changes can generate:

- lifetime benefits for Class 1 dwellings of:
   - between $229 (in CZ2 in Queensland) and $3,197 (in CZ1 in the Northern Territory) under Option A
   - between $41 (in CZ2 in Queensland) and $2,398 (in CZ81 in Victoria) under Option B
- lifetime benefits for Class 2 dwellings of:
   - between $441 (in CZ5 in Western Australia) and $2,052 (in CZ1 in the Northern Territory) under Option A
   - between $118 (in CZ2 in NSW) and $1,070 (in CZ1 in the Northern Territory) under Option B.

[229] Notably, a number of Class 2 dwellings under Option B experience annual increases in electricity consumption, but an overall decrease in total electricity consumption over 2022 2060. Increases in electricity consumption in these dwellings last for 12 years (until 2033) and then decreases in electricity consumption are experienced from 2034 onwards. The small increase in consumption in the first few years is due to water heating equipment, which is assumed to have a lifespan of 12 years. After this equipment reaches its assumed end-of-life, these increases in electricity use end, and decreases in electricity from other sources remain for a much longer period, resulting in overall decreases in electricity over the period of analysis.

Table 6.8 Estimated changes in energy consumption for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option A, MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ)				Total PV exports (2022-2060, MJ)
		Electricity	Gas	LPG and firewood	Total		Electricity	Gas	LPG and firewood	Total	
NSW	2	-1,909	-137	-6	-2,051	4,578	-39,909	-2,055	-169	-42,133	91,555
NSW	4	-3,569	-324	-49	-3,941	6,475	-80,104	-6,583	-1,460	-88,147	129,505
NSW	5	-3,192	-285	-23	-3,500	5,654	-69,273	-5,363	-695	-75,331	113,078
NSW	6	-3,773	-533	-119	-4,425	6,309	-82,045	-12,380	-3,575	-98,000	126,183
NSW	7	-3,827	-538	-93	-4,459	5,696	-88,136	-12,836	-2,801	-103,773	113,914
NSW	8	-5,342	-1,254	-251	-6,847	9,575	-121,392	-32,718	-7,544	-161,654	191,494
VIC	4	-2,408	-2,251	-121	-4,780	3,938	-52,355	-59,249	-3,634	-115,237	78,770
VIC	6	-1,337	-7,845	-298	-9,480	3,773	-17,656	-233,584	-8,934	-260,174	75,465
VIC	7	-1,611	-8,520	-251	-10,382	4,208	-24,987	-253,514	-7,516	-286,018	84,158
VIC	8	-2,738	-13,029	-550	-16,316	8,922	-47,802	-390,856	-16,495	-455,153	178,435
QLD	1	-2,933	-27	-0	-2,960	202	-42,701	-325	-1	-43,027	4,033
QLD	2	-1,180	-32	-4	-1,216	148	-16,599	-461	-115	-17,175	2,969
QLD	3	-3,148	-32	-8	-3,188	222	-47,611	-453	-245	-48,310	4,435
QLD	5	-2,987	-44	-16	-3,047	155	-41,432	-786	-472	-42,690	3,090
SA	4	-1,960	-885	-200	-3,045	2,092	-41,785	-22,000	-6,013	-69,798	41,836
SA	5	-1,802	-708	-93	-2,603	1,888	-38,455	-16,666	-2,782	-57,903	37,758
SA	6	-2,358	-1,744	-497	-4,599	2,907	-48,254	-47,884	-14,905	-111,043	58,148
WA	1	-1,649	-454	-0	-2,103	1,883	-35,381	-5,455	-2	-40,838	37,668
WA	3	-2,030	-667	-20	-2,717	2,195	-45,465	-11,735	-601	-57,801	43,904

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ)				Total PV exports (2022-2060, MJ)
		Electricity	Gas	LPG and firewood	Total		Electricity	Gas	LPG and firewood	Total	
WA	4	-1,201	-1,538	-82	-2,821	1,324	-24,344	-36,852	-2,457	-63,653	26,482
WA	5	-983	-1,398	-48	-2,429	1,353	-18,422	-33,149	-1,435	-53,006	27,065
WA	6	-1,374	-2,794	-220	-4,387	1,863	-24,751	-74,050	-6,587	-105,388	37,263
TAS	7	-3,694	-634	-830	-5,158	1,796	-59,213	-14,624	-24,910	-98,747	35,930
NT	1	-6,655	-0	0	-6,655	6,933	-163,743	-1	0	-163,744	138,663
NT	3	-2,829	-38	-2	-2,869	1,937	-63,204	-457	-64	-63,725	38,731
ACT	7	-2,156	-1,359	-57	-3,571	1,495	-39,665	-31,668	-1,700	-73,032	29,900

Note: Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

Table 6.9 Estimated changes in energy consumption for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option B, MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ)				Total PV exports (2022-2060, MJ)
		Electricity	Gas	LPG and firewood	Total		Electricity	Gas	LPG and firewood	Total	
NSW	2	-397	-68	-6	-471	918	-8,644	-1,273	-169	-10,087	18,359
NSW	4	-993	-234	-49	-1,276	1,379	-24,310	-5,767	-1,460	-31,538	27,572
NSW	5	-770	-190	-23	-983	1,191	-17,841	-4,437	-695	-22,973	23,817
NSW	6	-941	-447	-119	-1,507	1,235	-22,428	-11,905	-3,575	-37,907	24,700

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ)				Total PV exports (2022-2060, MJ)
		Electricity	Gas	LPG and firewood	Total		Electricity	Gas	LPG and firewood	Total	
NSW	7	-966	-431	-93	-1,490	1,335	-23,342	-11,546	-2,801	-37,690	26,691
NSW	8	-4,043	-1,364	-251	-5,659	6,833	-95,266	-35,958	-7,544	-138,767	136,658
VIC	4	-994	-2,707	-121	-3,822	437	-17,417	-72,205	-3,634	-93,256	8,748
VIC	6	-628	-5,571	-298	-6,497	830	-7,511	-159,272	-8,934	-175,717	16,596
VIC	7	-728	-5,607	-251	-6,585	364	-7,998	-159,250	-7,516	-174,765	7,287
VIC	8	2,013	-24,814	-550	-23,350	1,783	75,305	-738,205	-16,495	-679,395	35,662
QLD	1	-408	-26	-0	-434	110	-12,239	-306	-1	-12,546	2,209
QLD	2	-120	-16	-4	-139	50	-3,517	-264	-115	-3,896	992
QLD	3	-537	-13	-8	-558	116	-15,974	-235	-245	-16,455	2,322
QLD	5	-294	-27	-16	-337	77	-8,738	-590	-472	-9,799	1,550
SA	4	-637	-819	-200	-1,656	231	-16,509	-22,755	-6,013	-45,277	4,628
SA	5	-551	-616	-93	-1,260	225	-13,982	-16,663	-2,782	-33,428	4,496
SA	6	-526	-1,646	-497	-2,669	183	-12,504	-47,305	-14,905	-74,714	3,654
WA	1	-529	-415	-0	-944	195	-12,155	-4,990	-2	-17,147	3,901
WA	3	-826	-546	-20	-1,393	231	-20,817	-8,851	-601	-30,269	4,610
WA	4	-620	-1,258	-82	-1,960	287	-12,585	-34,018	-2,457	-49,060	5,745
WA	5	-442	-1,136	-48	-1,626	273	-7,678	-30,519	-1,435	-39,633	5,468
WA	6	-732	-2,791	-220	-3,743	965	-14,110	-73,984	-6,587	-94,681	19,306
TAS	7	-1,191	-532	-830	-2,553	266	-23,642	-13,398	-24,910	-61,950	5,311
NT	1	-2,874	-32	0	-2,906	1,370	-71,095	-385	0	-71,480	27,391
NT	3	-1,483	-8	-2	-1,493	107	-34,999	-100	-64	-35,163	2,134

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ)				Total PV exports (2022-2060, MJ)
		Electricity	Gas	LPG and firewood	Total		Electricity	Gas	LPG and firewood	Total	
ACT	7	-795	-1,095	-57	-1,947	242	-15,126	-28,497	-1,700	-45,323	4,842

Note: Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.10 Estimated changes in energy consumption for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option A, MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Change in energy consumption, total 2022-2060 (MJ)			
		Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
NSW	2	345[a]	-6,952	-0	-6,606	-2,597	-83,488	-0	-86,085
NSW	4	-128	-7,217	-0	-7,345	-16,159	-87,690	-2	-103,851
NSW	5	261[a]	-7,094	-0	-6,833	-4,904	-85,366	-0	-90,270
NSW	6	488[a]	-8,320	-0	-7,832	-4,802	-100,632	-1	-105,435
NSW	7	-325	-8,626	-0	-8,950	-26,672	-105,598	-4	-132,273
VIC	6	1,235	-9,666	0	-8,431	1,817	-120,922	0	-119,105
VIC	7	584[a]	-10,380	0	-9,796	-16,458	-137,051	0	-153,509
QLD	1	-6,193	-316	0	-6,509	-104,581	-3,798	0	-108,379
QLD	2	-4,885	-317	0	-5,203	-69,282	-3,825	0	-73,108
QLD	5	-5,058	-326	0	-5,384	-71,676	-3,974	0	-75,650
SA	5	399[a]	-7,857	0	-7,458	-3,389	-100,263	0	-103,652

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Change in energy consumption, total 2022-2060 (MJ)			
		Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
WA	5	792	-8,184	0	-7,392	2,681	-104,936	0	-102,255
TAS	7	-3,998	-2,567	0	-6,566	-55,928	-35,504	0	-91,432
NT	1	-4,649	-197	0	-4,845	-98,509	-2,359	0	-100,868
ACT	7	-1,650	-5,589	0	-7,239	-29,905	-76,036	0	-105,942

[a] Notably, a number of Class 2 dwellings under Option B experience annual increases in electricity consumption, but an overall decrease in total electricity consumption over 2022 2060. Increases in electricity consumption in these dwellings last for 12 years (until 2033) and then decreases in electricity consumption are experienced from 2034 onwards. The small increase in consumption in the first few years is due to water heating equipment, which is assumed to have a lifespan of 12 years. After this equipment reaches its assumed end-of-life, these *marginal* increases in electricity use end (the water heater's energy consumption return to baseline levels), and decreases in electricity from other sources remain for a much longer period, resulting in overall decreases in electricity over the period of analysis.

Note: Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.11 Estimated changes in energy consumption for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option B, MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ)				Change in energy consumption, total 2022-2060 (MJ)			
		Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
NSW	2	-389	-335	0	-723	-2,597	-83,488	-0	-86,085
NSW	4	-626	-439	-0	-1,065	-16,159	-87,690	-2	-103,851
NSW	5	-485	-382	-0	-868	-10,423	-4,824	-0	-15,248
NSW	6	-562	-429	-0	-991	-12,273	-5,859	-1	-18,133
NSW	7	-991	-525	-0	-1,517	-24,566	-8,393	-3	-32,962
VIC	6	-333	-1,405	0	-1,738	-8,929	-20,417	0	-29,346
VIC	7	-540	-1,821	0	-2,361	-14,203	-34,344	0	-48,547
QLD[a]	1	-4,268	-314	0	-4,582	-59,326	-3,770	0	-63,095
QLD[a]	2	-3,901	-317	0	-4,218	-48,884	-3,824	0	-52,708
QLD[a]	5	-4,189	-326	0	-4,515	-54,333	-3,969	0	-58,302
SA	5	-1,052	-860	0	-1,912	-16,397	-16,236	0	-32,633
WA	5	-738	-991	0	-1,729	-11,576	-18,669	0	-30,245
TAS	7	-3,210	-523	0	-3,734	-44,542	-10,946	0	-55,488
NT	1	-2,892	-27	0	-2,919	-40,164	-328	0	-40,491
ACT	7	-1,545	-890	0	-2,435	-22,595	-19,350	0	-41,946

[b] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Resetting the benchmark to gas instantaneous for Class 2 dwellings in Queensland under Option B would increase total annual energy consumption for apartments in Queensland CZ1 by 3,156 MJ, CZ2 by 2,923 MJ and CZ5 by 3,088 MJ.

Note: Estimates for a ‘composite’ dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.12 Estimated present value of energy benefits over 2022-2060 for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option A, $/dwelling ($2021)

Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total
NSW	2	492	13	1	505
NSW	4	958	35	9	1,002
NSW	5	841	29	4	875
NSW	6	993	61	23	1,078
NSW	7	1,041	63	18	1,122
NSW	8	1,440	155	48	1,643
VIC	4	727	263	23	1,014
VIC	6	316	996	57	1,369
VIC	7	411	1,082	48	1,540
VIC	8	742	1,663	105	2,510
QLD	1	572	2	0	574
QLD	2	226	3	1	229
QLD	3	629	3	2	633
QLD	5	566	4	3	573
SA	4	625	104	38	767
SA	5	576	81	18	675
SA	6	740	218	95	1,053
WA	1	310	28	0	337
WA	3	389	49	4	441
WA	4	217	133	16	366
WA	5	171	120	9	300
WA	6	235	257	42	534
TAS	7	758	75	158	991
NT	1	3,197	0	0	3,197
NT	3	1,285	2	0	1,288
ACT	7	492	157	11	660

Note: Present values at 7 per cent discount rate. Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Negative numbers reflect negative energy savings (i.e. increase energy costs) when compared to the baseline. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.13 Estimated present value of energy benefits over 2022-2060 for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option B, $/dwelling ($2021)

Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total
NSW	2	105	7	1	113
NSW	4	280	28	9	317
NSW	5	210	22	4	237
NSW	6	261	56	23	340
NSW	7	270	54	18	342
NSW	8	1,117	170	48	1,335
VIC	4	253	320	23	595
VIC	6	133	688	57	878
VIC	7	142	690	48	880
VIC	8	-856	3,149	105	2,398
QLD	1	133	2	0	135
QLD	2	38	1	1	41
QLD	3	174	1	2	177
QLD	5	95	3	3	101
SA	4	227	103	38	369
SA	5	194	76	18	288
SA	6	177	212	95	484
WA	1	101	25	0	127
WA	3	167	38	4	209
WA	4	111	117	16	243
WA	5	73	105	9	187
WA	6	130	257	42	429
TAS	7	275	66	158	500
NT	1	1,366	2	0	1,368
NT	3	680	1	0	681
ACT	7	183	135	11	329

Note: Present values at 7 per cent discount rate. Estimates for a ‘composite’ dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Negative numbers reflect negative energy savings (i.e. increase energy costs) when compared to the baseline. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.14 Estimated present value of energy benefits over 2022-2060 for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option A, $/dwelling ($2021)

Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total
NSW	2	-2	576	0	575
NSW	4	144	601	0	746
NSW	5	23	589	0	612
NSW	6	4	692	0	696
NSW	7	242	721	0	963
VIC	6	-129	746	0	617
VIC	7	96	822	0	918
QLD	1	1,347	25	0	1,371
QLD	2	947	25	0	972
QLD	5	979	26	0	1,004
SA	5	-9	653	0	644
WA	5	-72	513	0	441
TAS	7	747	228	0	975
NT	1	2,040	12	0	2,052
ACT	7	364	489	0	854

Note: Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Present values at 7 per cent discount rate. Estimates for a 'composite' dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Negative numbers reflect negative energy savings (i.e. increase energy costs) when compared to the baseline. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.15 Estimated present value of energy benefits over 2022-2060 for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option B, $/dwelling ($2021)

Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total
NSW	2	91	28	0	118
NSW	4	164	39	0	203
NSW	5	121	32	0	153
NSW	6	142	38	0	179
NSW	7	274	50	0	323
VIC	6	112	117	0	228

Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total
VIC	7	179	174	0	353
QLD[a]	1	812	25	0	836
QLD[a]	2	694	25	0	719
QLD[a]	5	761	26	0	787
SA	5	270	87	0	356
WA	5	115	75	0	190
TAS	7	597	58	0	655
NT	1	1,068	2	0	1,070
ACT	7	297	99	0	396

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Resetting the benchmark to gas instantaneous for Class 2 dwellings in Queensland under Option B would reduce the total energy savings for apartments in Queensland CZ1 to $291, CZ2 to $239 and CZ5 to $275.

Note: Present values at 7 per cent discount rate. Estimates for a ‘composite’ dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Negative numbers reflect negative energy savings (i.e. increase energy costs) when compared to the baseline. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

6.3 Net impacts on dwellings

The net impacts for each composite dwelling in the sample under each policy option are provided in Table 6.16 and Table 6.17. The net impact is an on-balance account of the overall lifetime impacts (costs and benefits) of the policy scenarios examined. The table provides estimates of the PVa of the costs and benefits, and both the NPV and the BCR of the policy change.

These tables indicate that:

— all the modelled dwellings (including Class 1 and Class 2) are estimated to experience a negative return from a societal perspective (i.e. measured using wholesale energy prices) under Option A

— all but one Class 1 of the modelled dwellings (in CZ1 in Western Australia), and all of the Class 2 dwellings modelled are estimated to experience a negative return from a societal perspective under Option B.

These results indicate that the estimated costs of compliance to society — given the compliance pathways selected under each policy option — are greater than the estimated lifetime energy savings.

These results are mainly driven by the use of wholesale energy prices (as a proxy for avoided resource costs) to value the benefits of reduced energy consumption which, as noted in Chapter 5, results in BCRs and NPVs that are much smaller than if retail energy prices are used. This effect is compounded by the recent period of low wholesale energy prices with a number of government policy initiatives incentivising the entry of new energy supply options and a reduction in the demand for energy.

Table 6.16 Estimated lifetime impacts (2022-2051) of proposed NCC policy options for Class 1 composite dwellings built in 2022 across different jurisdictions and climate zones modelled ($2021)

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
Option A					
NSW	2	1,888	505	-1,383	0.3
NSW	4	2,336	1,002	-1,333	0.4
NSW	5	3,230	875	-2,355	0.3
NSW	6	2,696	1,078	-1,618	0.4
NSW	7	2,663	1,122	-1,541	0.4
NSW	8	4,063	1,643	-2,419	0.4
VIC	4	1,879	1,014	-865	0.5
VIC	6	2,233	1,369	-864	0.6
VIC	7	2,780	1,540	-1,240	0.6
VIC	8	3,824	2,510	-1,314	0.7
QLD	1	678	574	-104	0.8
QLD	2	516	229	-287	0.4
QLD	3	511	633	122	1.2
QLD	5	1,237	573	-664	0.5
SA	4	1,556	767	-788	0.5
SA	5	1,312	675	-637	0.5
SA	6	1,847	1,053	-795	0.6
WA	1	562	337	-224	0.6
WA	3	642	441	-200	0.7
WA	4	846	366	-480	0.4
WA	5	739	300	-439	0.4
WA	6	959	534	-425	0.6
TAS	7	2,424	991	-1,433	0.4
NT	1	5,863	3,197	-2,666	0.5
NT	3	1,850	1,288	-562	0.7
ACT	7	773	660	-114	0.9

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
Option B					
NSW	2	696	113	-583	0.2
NSW	4	540	317	-223	0.6
NSW	5	1,407	237	-1,170	0.2
NSW	6	458	340	-118	0.7
NSW	7	834	342	-492	0.4
NSW	8	3,012	1,335	-1,678	0.4
VIC	4	857	595	-261	0.7
VIC	6	952	878	-74	0.9
VIC	7	1,299	880	-419	0.7
VIC	8	1,748	2,398	649	1.4
QLD	1	89	135	46	1.5
QLD	2	247	41	-207	0.2
QLD [a]	3	-111	177	288	NA
QLD	5	670	101	-569	0.2
SA	4	578	369	-209	0.6
SA	5	516	288	-228	0.6
SA	6	357	484	127	1.4
WA	1	164	127	-37	0.8
WA	3	244	209	-35	0.9
WA	4	476	243	-233	0.5
WA	5	370	187	-183	0.5
WA	6	589	429	-160	0.7
TAS	7	1,252	500	-753	0.4
NT	1	1,677	1,368	-309	0.8
NT	3	437	681	243	1.6
ACT	7	195	329	134	1.7

[a] BCR cannot be calculated for this dwelling as the dwelling does note experience any costs, only benefits.

Note: Present values at 7 per cent discount rate. Estimates for a ‘composite’ dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 6.17 Estimated lifetime impacts (2022-2051) of proposed NCC policy options for Class 2 composite dwellings built in 2022 across different jurisdictions and climate zones modelled ($2021)

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
Option A					
NSW	2	3,781	575	-3,206	0.2
NSW	4	3,616	746	-2,870	0.2
NSW	5	3,897	612	-3,285	0.2
NSW	6	3,707	696	-3,011	0.2
NSW	7	4,238	963	-3,275	0.2
VIC	6	4,189	617	-3,573	0.1
VIC	7	4,476	918	-3,558	0.2
QLD[a]	1	4,540	1,371	-3,169	0.3
QLD[a]	2	4,503	972	-3,531	0.2
QLD[a]	5	4,531	1,004	-3,527	0.2
SA	5	3,070	644	-2,425	0.2
WA	5	2,587	441	-2,146	0.2
TAS	7	1,895	975	-920	0.5
NT	1	4,346	2,052	-2,293	0.5
ACT	7	2,600	854	-1,746	0.3
Option B					
NSW	2	398	118	-280	0.3
NSW	4	251	203	-48	0.8
NSW	5	520	153	-367	0.3
NSW	6	358	179	-179	0.5
NSW	7	884	323	-560	0.4
VIC	6	487	228	-258	0.5
VIC	7	795	353	-442	0.4
QLD[a, b]	1	1,489	836	-653	0.6
QLD[a, b]	2	1,590	719	-871	0.5
QLD[a, b]	5	1,759	787	-973	0.4
SA	5	527	356	-171	0.7
WA	5	227	190	-37	0.8
TAS	7	904	655	-249	0.7

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
NT	1	1,144	1,070	-74	0.9
ACT	7	760	396	-364	0.5

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[b] Resetting the benchmark to gas instantaneous for Class 2 dwellings in Queensland under Option B would result in the following impacts for apartments in Queensland: in CZ1 a net impact of -$129 and a BCR of 0.7, in CZ2 a net impact of -$454 and a BCR of 0.3 and in CZ5 a net impact of -$568 and a BCR of 0.3.

Note: Present values at 7 per cent discount rate. Estimates for a ‘composite’ dwelling for climate zones/jurisdiction that accounts for the number of dwellings that would take each of the upgrade pathways described in Chapter 5. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

7 Economy-wide analysis: national impacts

The previous chapter considered the impacts of the proposed NCC changes at a dwelling level. This chapter considers the overall costs and benefits of the proposed changes at the Australia-wide level.

7.1 Economy-wide costs

The proposed changes to the energy efficiency requirements in the NCC would involve substantial costs for the Australian economy. Costs at the economy-wide level include:

— an aggregation of those costs incurred by individual dwellings

— costs incurred by government to administer the policy and communicate the policy changes

— costs incurred by industry that cannot be directly passed on to the consumer (such as training costs).

These are discussed in more detail in the sections below.

7.1.1 Change in construction costs

The aggregate capital costs associated with the proposed policy changes are summarised in Table 7.1. Most capital costs (except for inverters as discussed in Chapter 5) are only incurred during the initial dwelling construction and therefore do not create a cohort effect as is the case with energy savings.

Table 7.1 Present value of state-wide capital costs to meet the NCC 2022 over 2022-2060, $M ($2021)

	Class 1	Class 2
Option A		
NSW	653.7	531.1
VIC	847.7	425.5
QLD [a]	198.4	299.8
SA	128.9	29.6
WA	175.0	83.2
TAS	59.7	1.7
NT	54.2	11.3
ACT	23.4	56.4
AUS	2,140.9	1,438.7

	Class 1	Class 2
Option B		
NSW	214.9	61.1
VIC	490.7	46.2
QLD [a, b]	83.7	127.1
SA	59.3	5.2
WA	100.1	8.2
TAS	33.0	0.9
NT	23.5	3.7
ACT	11.1	16.4
AUS	1,016.4	268.9

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[b] Resetting the energy performance benchmark for Class 2 dwellings in Queensland to be the same as all other states would decrease the costs under Option B to $50.3 million.

Note: Present values at 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

As set out in Table 7.1, it is estimated that the proposed energy efficiency changes to the NCC would impose Australia-wide costs of $3.6 billion over the life of the policy under Option A and $1.3 billion in costs under Option B.

As noted before, these estimates take into account the costs:

— of changes to equipment and the building shell to meet the new energy efficiency requirements
— of thermal bridging mitigation measures
— associated with improving the thermal shell from 6 to 7 stars for buildings on difficult blocks
— that are saved from using smaller equipment as a result of improving the thermal shell from 6 to 7 stars.

7.1.2 Implementation costs for industry

As discussed before, reflecting the nature of the feedback received during consultation, the economy-wide analysis includes the following costs for industry:

1. Training costs — these are one-off costs incurred by industry stakeholders to familiarise themselves with the new requirements in the NCC.
2. Redesign costs for volume builders — these are one-off costs that relate to:
   – redesigning buildings plans and specifications
   – limited access to new technology (e.g. windows with in-line reveal that reduce the thermal bridging through aluminium frames) as a result of existing supply contracts.

3. Transition costs for custom builders — these are one-off costs that relate to additional time needed by assessors and designers to optimise 7 star designs to contain construction costs increases. These transitional costs will reflect the fact that the long run costs used in the DRIS technical modelling will not be achieved from the start of the regulation. As noted before, these costs could be minimised through a transitional period.
4. Administrative costs – these costs reflect the additional time needed to integrate the WOH requirements.

Additional details about how these costs have been included in the DRIS are provided below.

Training costs

These costs were accounted for in the CRIS and include:

— the time invested by industry in familiarising themselves with the relevant new targets

— any fees associated with attending associated professional development seminars.

To calculate the training cost associated with the proposed changes to the NCC, we estimated:

— the number of industry stakeholders in the residential construction industry directly affected by the proposed changes

— the training costs projected to be incurred by each stakeholder.

Stakeholders directly affected by the proposed changes

The main stakeholder groups that are likely to be directly affected by the proposed changes to the NCC and would need to undertake training to understand the proposed changes are:

— construction managers

— architects and building designers

— building surveyors

— thermal performance (NatHERS) assessors.

The estimated number of these stakeholders that are involved in the construction of residential buildings in different jurisdictions is outlined in Table 7.2. These figures have been updated for the DRIS and were derived using estimates of the number of people in each relevant occupation Australia-wide sourced from two recent RISs related to changes in the NCC[230,231], escalating these numbers to 2022 using ABS estimates of employment growth in the Australian construction industry, and splitting them by jurisdiction using estimates of the share of residential construction employment by state, derived from Input-Output (IO) tables. The total number of current NatHERS assessors

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[230] Strategy. Policy. Research (SPR) 2018, *Inclusion of heating and cooling energy load limits in NatHERS assessments, Regulation Impact Statement for decision*, prepared for the Australian Building Codes Board.

[231] Centre for International Economics (CIE) 2021, *Proposal to include minimum accessibility standards for housing in the National Construction Code, Decision Regulation Impact Statement*, prepared for the Australian Building Codes Board, February.

across Australia was sourced from the Assessor Accrediting Organisations (AAOs) and split by state using IO tables.

Table 7.2 Estimated number of industry stakeholders directly affected by the proposed changes to the NCC, 2020

Occupation	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Construction managers	13,627	11,478	7,634	2,367	3,723	707	231	588	40,354
Architects & building designers	3,512	2,958	1,967	610	959	182	60	152	10,399
Building surveyors	574	484	322	100	157	30	10	25	1,701
NatHERS assessors	270	228	151	47	74	14	5	12	800
Total	**17,983**	**15,147**	**10,074**	**3,123**	**4,913**	**933**	**305**	**776**	**53,254**

Note: Totals may not add up due to rounding.

Source: ACIL Allen based on information sourced from AAOs; CIE 2021, Proposal to include minimum accessibility standards for housing in the National Construction Code, Decision Regulation Impact Statement; SPR 2018, Inclusion of heating and cooling energy load limits in NatHERS assessments, Regulation Impact Statement for decision; and ABS data.

Training costs incurred by each stakeholder

As noted above, the training costs incurred by affected stakeholders include:

— the time required for training

— the fees associated with attending formal training (e.g. for professional development seminars).

Based on assumptions used for commercial energy efficiency for changes of a similar magnitude[232], it has been assumed that each person who requires retraining would require a total of 9.5 hours of training, including:

— 2 hours to attend a seminar/webcast to explain the proposed changes

— 3.75 hours of Continuous Professional Development (CPD)[233]

— 3.75 hours of self-paced learning.

In addition to this, it has been assumed that 20 per cent of architects and building designers would also undertake four hours of additional training on how 7-stars will affect the development of cost-effective design solutions.

[232] Centre for International Economics (CIE) 2018, *Decision Regulation Impact Statement Energy Efficiency in Commercial Buildings*, prepared for ABCB, 20 November 2018.

[233] It is assumed that this CPD training is additional to other training that would otherwise occur (i.e. that this retraining does not replace other training that would have occurred).

The opportunity cost of this time has been valued using estimates of hourly earnings for each of the affected occupations adjusted to exclude tax[234] and to include an on-cost multiplier of 1.75 to account for non-wage labour on-costs.[235] In response to feedback from consultation, the wage assumptions used in the industry cost analysis were reviewed to reflect the most recent official data.

The most recent earnings data was sourced from the National Skills Commission's Labour Market Insights (LMI) website[236], which provides up-to-date information about the Australian jobs market based on ABS data. This data represents the median pay for full-time employees in 2021 paid at the adult rate, before tax, including amounts salary sacrificed. The updated indicative hourly earnings used to value the time invested in training for occupations undertaking retraining are outlined in Table 7.3.

Table 7.3 Indicative hourly earnings for occupations requiring retraining

	CRIS		DRIS	
	$/hr 2021, excl. taxation	$/hr 2021, including on-costs	$/hr 2021, excl. taxation	$/hr 2021, including on-costs
Construction managers	61.68	107.94	62.4	109.2
Architects and building designers	35.39	61.93	38.4	67.2
Building surveyors	41.46	72.55	40.8	71.4
NatHERS assessors	39.13	68.47	40.0	70.1

Note: assumes 230 working days per year and 7.5 hours per working day.

Source: ACIL Allen estimates based on information sourced from the National Skills Commission's Labour Market Insights website.

In addition to the time costs, industry stakeholders would incur CPD seminar fees. It has been assumed that the cost per hour of CPD training is $50 (excluding GST). This assumption is in line with what is currently charged by industry organisations providing training to members.

The total estimated training costs for industry stakeholders by jurisdiction are presented in Table 7.4.

[234] As noted before, taxation is excluded from the analysis as it is a transfer to government (not a cost). The earnings data is multiplied by 0.8, which is equivalent to assuming each of these individuals has an average tax rate of 20 per cent.

[235] The Commonwealth Regulatory Burden Measurement Framework Guidance Note by the Office of Best Practice Regulation (OBPR, p.11) states that average weekly earnings need to be ‘scaled up using a multiplier of 1.75 (or 75 per cent as it is input into the Regulatory Burden Measure) to account for the non-wage labour on-costs (for example, payroll tax and superannuation) and overhead costs (for example, rent, telephone, electricity and information technology equipment expenses).'

[236] https://labourmarketinsights.gov.au/

Table 7.4 Estimated total retraining costs for industry (including training time and training fees), $M ($2021)

Occupation	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
Construction managers	16.78	14.13	9.40	2.91	4.58	0.87	0.28	0.72	49.69
Architects & building designers	3.18	2.68	1.78	0.55	0.87	0.17	0.05	0.14	9.43
Building surveyors	0.50	0.42	0.28	0.09	0.14	0.03	0.01	0.02	1.48
NatHERS assessors	0.23	0.20	0.13	0.04	0.06	0.01	0.00	0.01	0.69
Total	**20.70**	**17.43**	**11.60**	**3.59**	**5.66**	**1.07**	**0.35**	**0.89**	**61.30**

Note: Totals may not add up due to rounding.
Source: ACIL Allen.

Redesign costs

In response to feedback from consultation, we have included one-off redesign costs for volume builders that reflect:

— the costs of redesigning buildings plans and specifications to meet the new requirements

— the possibility of higher costs than those used in the technical modelling due to limited access to new technology (e.g. windows with in-line reveal that reduce the thermal bridging through aluminium frames) as a result of existing supply contracts which cannot be changed in the short term (which typically last 2-3 years).

To account for these costs, we have used a similar approach to that used in the RIS assessing the impacts of the proposal to add separate heating and cooling load limits to the NatHERS compliance pathway for the energy performance of residential buildings in 2018.[237] To account for redesign, the heating and cooling DRIS allowed for one-off redesign costs to be incurred over the whole 10 years for the regulatory option (by which time, standard designs should have been adjusted). It was assumed that these costs would be incurred by up to 20 per cent of the cohorts of buildings for which assessments are done at the last minute (after final drawings and client approvals), with an allowance of 2 hrs at $150/hr for incremental energy assessment/redesign costs per (relevant) design. Given that these are one-off time costs associated with modifying existing designs, the stock of existing designs that remain unmodified diminishes over time and as such the DRIS assumed a linear (rather than exponential) reduction in the stock of unmodified existing designs, such that no unmodified designs remain after 10 years.

In this DRIS, redesign costs have been estimated assuming the following:

— volume-built houses that rely on pre-existing designs incur one-off redesign costs, while brand new designs drawn after the implementation of the proposed regulation do not (the costs of designers learning the new regulations in order to produce compliant designs are captured in the costs of retraining discussed above)

[237] Strategy. Policy. Research (SPR) 2018, *Inclusion of heating and cooling energy load limits in NatHERS assessments, Regulation Impact Statement for decision*, prepared for the Australian Building Codes Board.

— volume-built houses represent 40 per cent of the home building market[238] (both for Class 1 and Class 2)
— a third of volume-built houses each year would experience redesign costs, so that by the third year of the regulation, the costs of redesigning all volume-built houses' designs have been accounted for (or 'old' designs superseded by new designs as part of the usual business cycle)
— an allowance of *eight hours* at $67.20/hr for incremental energy assessment/redesign costs (the earnings of architects and builder designers including on-costs as per Table 7.4) per (relevant) design.

The total estimated redesign costs for volume builders are presented in Table 7.5. Importantly, our view is that the assumptions used to estimate these costs result in a conservative estimate of these costs given that:

— an allowance of eight hours per design for optimisation to specifications for roof colour, floor coverings or window specifications which were applied in the technical modelling by TIC is considered generous
— redesign costs are applied to a third of volume-built houses each year, but volume builders construct several dwellings under each design
  – as shown in Table 7.5, the estimated redesign costs assume that around 20,000 designs will revised every year over three years (a total of over 63,000 designs)
  – when eight hours of redesign are applied to a third of dwellings constructed by volume builders in a typical year, this allowance equates to more than half a million hours of redesign over three years. This time allowance would increase at the rate of 1 week for every 15 dwellings in proportion to the number of dwellings constructed under a single design (see Figure 7.1)
— once architects and building designers have been redesigning and re-rating for 12 months, most will have learned how to accommodate the new regulatory requirements and transfer this knowledge to the next project. The additional cost after that will start to diminish.

As noted before, redesign costs can be reduced by having a transition period for the introduction of the proposed standards.

Table 7.5 Estimated redesign costs for volume-built dwellings, Australia

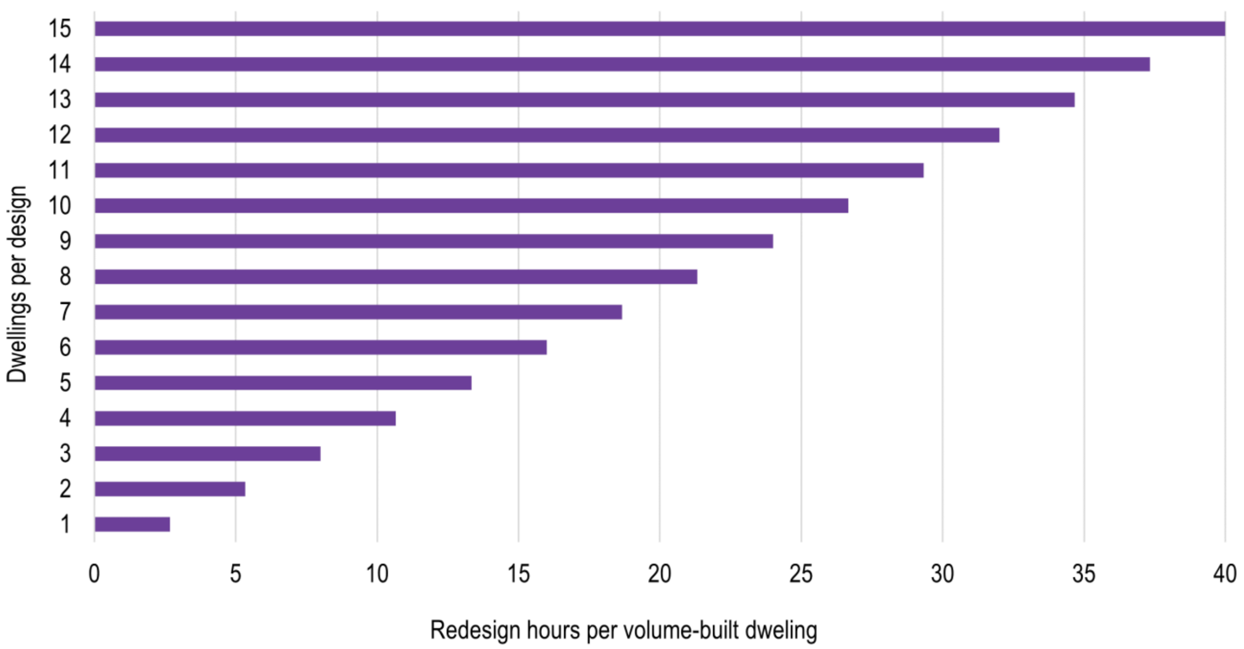
	2022	2023	2024
Total new dwellings built, No.			
Class 1	119,982	120,629	129,562
Class 2	31,703	33,459	37,782
Total	151,685	154,088	167,344
Total volume buildings built, No.			
Class 1	47,993	48,252	51,825
Class 2	12,681	13,384	15,113
Total	60,674	61,635	66,938

[238] This was an estimate provided in HIA's submission.

	2022	2023	2024
Volume buildings affected by redesign, No.			
Class 1	15,998	16,084	17,275
Class 2	4,227	4,461	5,038
Total	20,225	20,545	22,313
Redesign costs, $M 2021			
Class 1	8.6	8.6	9.3
Class 2	2.3	2.4	2.7
Total	10.9	11.0	12.0

Source: ACIL Allen.

Figure 7.1 Redesign hours per volume-built dwelling



Source: ACIL Allen.

Transition costs for custom builders

As noted previously in this document, the costs estimated in the DRIS's technical work represent long run costs achieved by:

— optimising designs to contain construction cost increases

— the use of new technology (e.g. windows with in-line reveal that reduce the thermal bridging through aluminium frames).

In contrast with volume-built dwellings, custom-built dwellings are likely to have access to innovative materials/new technology in the short term because they are not restricted by supply contracts.

However, there will be one-off costs that relate to additional time needed by assessors and designers to optimise 7 star designs to contain construction costs increases. The potential for these higher costs in the short term is recognised in the DRIS via additional transitional costs for custom-built dwellings. Transition costs have been estimated assuming the following:

- these costs are incurred by custom-built dwellings (which represent 60 per cent of the home building market)
- an allowance of *eight hours* at $67.20/hr for incremental energy assessment/redesign costs (the earnings of architects and builder designers including on-costs as per Table 7.4) per custom-built dwelling
- consistent with the overall approach used for the baseline in the DRIS, it was assumed that the proportion of dwellings that currently over comply with the current energy efficiency provisions is maintained under the new regulation. It will also be assumed that these dwellings will incur lower or no transitional costs, as it is assumed that, in a competitive market, these houses are already being built using a ‘lowest cost approach’. Specifically, it was assumed that:
  - dwellings currently built at 6 stars or below will incur 100 per cent of the transitional costs
  - dwellings currently built between at 6.5 and 7 stars will incur 50 per cent of the transitional costs
  - dwellings currently built at 7.5 and above will not incur any transitional costs.
- transitional costs will be assumed to be incurred for three years. That is, by the fourth year of the regulation, it is reasonable to expect that builders will be able to access the long run costs modelled in the central case of the RIS.

The total estimated transitional costs for custom builders are presented in Table 7.6.

Table 7.6 Estimated transitional costs for custom -built dwellings, 2022-2024, Australia

	2022	2023	2024
Total new dwellings built (No.)			
Class 1	119,982	120,629	129,562
Class 2	31,703	33,459	37,782
Total	151,685	154,088	167,344
Custom- built dwellings affected by transition costs (No.)			
<=6 stars	62,649	63,324	68,510
6.5 stars	12,326	12,525	13,616
Total	74,975	75,850	82,126
Transition costs $M 2021			
<=6 stars	33.7	34.0	36.8
6.5 stars	3.3	3.4	3.7
Total	37.0	37.4	40.5

Source: ACIL Allen.

Administrative costs

These costs refer to the incremental costs associated with including new data as a part of a NatHERS assessment to verify compliance with the new minimum requirements (including WoH). Costs have been estimated based on feedback from the NatHERS Administrator assuming the following:

— these costs are incurred by all new dwellings (both Class 1 and 2 dwellings, irrespective of whether these are volume or custom-built or the star rating of the dwelling under the BAU) built over 10 years (the assumed effective life of the regulation)

— the marginal additional data required by a whole-of-home NatHERS assessment adds around 20 data points, or less than 10 per cent increase over an existing design

— an allowance of *15 minutes* at $67.20/hr for incremental energy assessment/redesign costs (the earnings of architects and builder designers including on-costs as per Table 7.4) per dwelling.

The above allowance is also applied for the proportion of designs following the NCC's elemental pathway. These can be assessed through an ABCB calculator with significantly fewer data points and therefore these estimates are considered highly conservative.

The total estimated administrative costs for all dwellings are presented in Table 7.7.

Table 7.7 Estimated administrative costs, 2022-2031, Australia

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total new dwellings built (No.)										
Class 1	119,982	120,629	129,562	141,437	149,157	145,734	140,296	136,276	132,739	130,261
Class 2	31,703	33,459	37,782	43,046	47,190	48,335	48,733	49,304	50,028	51,123
Total	151,685	154,088	167,344	184,483	196,348	194,069	189,029	185,580	182,767	181,384
Administrative costs $M 2021										
All buildings	**2.55**	**2.59**	**2.81**	**3.10**	**3.30**	**3.26**	**3.18**	**3.12**	**3.07**	**3.05**

Source: ACIL Allen.

Total industry costs

The total costs for industry included in the economy-wide modelling as a result of the proposed changes to the NCC are summarised in Table 7.8.

Table 7.8 Estimated industry costs, 2022-231, Australia, $m 2021

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Estimated total retraining costs	61.3										61.3
Redesign costs (volume builders)	10.9	11.0	12.0	-	-	-	-	-	-	-	33.9
Transition costs (custom builders)	37.0	37.4	40.5	-	-	-	-	-	-	-	114.9

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Administrative costs	2.5	2.6	2.8	3.1	3.3	3.3	3.2	3.1	3.1	3.0	30.0
Total costs	**111.7**	**51.0**	**55.3**	**3.1**	**3.3**	**3.3**	**3.2**	**3.1**	**3.1**	**3.0**	**240.1**

Source: ACIL Allen.

7.1.3 Government costs

Costs to government are estimated to be $621,000. These costs include the following.

— Costs to be incurred by the ABCB to assist with the transition to the new code. These costs include preparation of a range of guidance material (e.g. fact sheets, design solutions, case studies) and presentations on the changes in all capital cities.

— Costs to be incurred by DISER to support the communication of the proposed changes.

These costs are assumed to be incurred as a once-off in 2022. While these costs would be incurred by the Australian Government, they have been apportioned by state using statistics of employment in residential construction by state. This notional allocation is necessary to complete the CBA by jurisdiction.

7.2 Economy-wide benefits

The economy-wide analysis uses three measures of the potential benefits accruing to each policy option:

1. **Energy benefits** — these are benefits from the saved cost of supplying energy. This is the most certain measure of benefits available and includes:
   – the aggregated value of direct energy savings from reduced energy consumption. Notably, in contrast to the household analysis, in the economy-wide analysis these benefits are valued using the resource cost (for which wholesale energy prices are used as a proxy)
   – an amenity benefit that offsets the rebound effect included in the modelling[239]
   – deferred investment in electricity generation and electricity and gas network capacity as a result of reductions in peak electricity demand and gas usage.
2. **Benefits from reduced carbon emissions** — this is a somewhat more uncertain measure of benefit. It is clear that carbon emissions represent a cost to society, and that reducing these emissions therefore represents a benefit. However, there is no universally agreed transparent price which can be assigned to these emissions.
3. **Health benefits from reduced electricity and gas generation** — these are benefits from reduced pollution from electricity and gas generation, and from wood and gas use. While it is clear that electricity generated from fossil fuels and that burning gas and wood produces air pollution that damages health, and that reducing these emissions represents a benefit, these benefits are generally regarded as highly uncertain and speculative and should be interpreted

[239] Refer to Section 5.5.1 for more details.

as an indicative potential value of the wellbeing that could be generated through energy efficiency upgrades. The true value in dollar terms of these benefits is unknown, but is expected, based on the information available, to be of the same order of magnitude as our estimates.

Each of these benefits is explained in more detail below. A discussion on benefits that have not been quantified for this RIS is provided in Section 9.1.

7.2.1 Energy savings

Table 7.9 summarises the estimated energy savings that would accrue to the Australian community as a result of the proposed policy changes. The energy saved from the policy change arises from two factors:

— how an individual dwelling is impacted by the policy (see Table 6.8 to Table 6.11)

— how the housing stock grows and develops over time (see Figure 5.4 and Figure 5.5).

As shown in Table 7.9**,** it is estimated that under Option A electricity consumption across Australia would decrease by about 128 PJ over the period of analysis, gas would decrease by around 138 PJ and LPG and firewood use would decrease by 5.4 PJ. The estimated reduction in energy consumption under Option B would be significantly smaller for electricity and gas and broadly the same for LPG and firewood. In particular, under Option B, electricity is estimated to reduce by 37.4 PJ, gas by around 77 PJ and LPG and firewood by 5.4 PJ.

The value of these energy reductions is also presented in Table 7.9**.** It is estimated that Option A would provide energy benefits to the Australian economy worth around $1.5 billion in present value terms, and Option B would deliver around $613 million in benefits.

Table 7.9 Estimated impacts of proposed NCC changes on energy consumption (2022-2060)

	Energy saved (PJ)				Present value of energy savings ($M, $2021)			
	Electricity	Gas	LPG and Firewood	Total	Electricity	Gas	LPG and Firewood	Total
Option A								
Class 1								
NSW	52.1	2.5	0.6	55.1	380.8	9.7	2.9	393.4
VIC	35.5	87.7	3.3	126.4	250.4	292.5	15.5	558.3
QLD	7.1	0.1	-	7.3	76.8	0.7	0.2	77.6
SA	7.7	1.9	0.4	10.1	64.8	7.2	1.9	73.9
WA	11.0	8.1	0.4	19.4	66.2	22.5	1.9	90.5
TAS	2.4	0.4	0.6	3.4	20.7	1.5	3.0	25.2
NT	3.1	-	-	3.1	44.0	-	-	44.0

	Energy saved (PJ)				Present value of energy savings ($M, $2021)			
	Electricity	Gas	LPG and Firewood	Total	Electricity	Gas	LPG and Firewood	Total
ACT	1.6	0.8	-	2.4	12.8	3.0	0.2	15.9
AUS	120.4	101.5	5.4	227.3	916.4	337.0	25.5	1,278.9
Class 2								
NSW	0.8	14.5	-	15.3	1.6	76.0	-	77.7
VIC	-0.2	14.9	-	14.7	-14.7	72.2	-	57.5
QLD [a]	5.7	0.3	-	6.0	64.7	1.6	-	66.3
SA	0.0	1.1	-	1.1	-0.1	5.5	-	5.3
WA	-0.1	3.7	-	3.6	-2.1	13.8	-	11.7
TAS	0.1	-	-	0.1	0.6	0.2	-	0.8
NT	0.3	-	-	0.3	4.5	-	-	4.6
ACT	0.7	1.8	-	2.5	7.2	9.0	-	16.2
AUS	7.3	36.3	-	43.6	61.8	178.3	-	240.1
Total								
NSW	52.9	16.9	0.6	70.4	382.5	85.8	2.9	471.1
VIC	35.2	102.6	3.3	141.1	235.7	364.6	15.5	615.8
QLD [a]	12.8	0.4	-	13.3	141.5	2.3	0.2	143.9
SA	7.8	3.1	0.4	11.2	64.6	12.6	1.9	79.2
WA	10.9	11.7	0.4	23.0	64.1	36.3	1.9	102.2
TAS	2.5	0.4	0.6	3.5	21.3	1.7	3.0	26.0
NT	3.4	-	-	3.4	48.5	-	-	48.6
ACT	2.3	2.6	-	5.0	20.0	12.0	0.2	32.2
AUS	127.7	137.8	5.4	270.9	978.2	515.3	25.5	1,519.0
Option B								
Class 1								
NSW	12.1	2.3	0.6	15.0	89.8	8.4	2.9	101.0
VIC	8.1	59.6	3.3	70.9	68.3	201.5	15.5	285.3
QLD	1.7	0.1	-	1.8	14.6	0.4	0.2	15.1
SA	1.8	2.0	0.4	4.2	17.8	6.9	1.9	26.5
WA	3.4	7.5	0.4	11.2	21.7	19.9	1.9	43.5
TAS	0.7	0.3	0.6	1.7	6.4	1.3	3.0	10.8
NT	0.9	-	-	0.9	12.8	-	-	12.8
ACT	0.5	0.7	-	1.2	4.2	2.5	0.2	6.9
AUS	29.3	72.4	5.4	107.0	235.6	241.0	25.5	502.1

	Energy saved (PJ)				Present value of energy savings ($M, $2021)			
	Electricity	Gas	LPG and Firewood	Total	Electricity	Gas	LPG and Firewood	Total
Class 2								
NSW	1.8	0.8	-	2.6	16.7	4.2	-	20.9
VIC	1.1	2.5	-	3.6	11.1	11.3	-	22.4
QLD [a, b]	4.0	0.3	-	4.3	47.3	1.6	-	48.9
SA	0.2	0.2	-	0.4	2.4	0.7	-	3.1
WA	0.4	0.7	-	1.1	3.2	2.0	-	5.2
TAS	-	-	-	0.1	0.5	-	-	0.5
NT	0.1	-	-	0.1	2.4	-	-	2.4
ACT	0.5	0.5	-	1.0	6.0	1.8	-	7.8
AUS	8.1	5.0	-	13.1	89.5	21.6	-	111.1
Total								
NSW	13.8	3.1	0.6	17.6	106.4	12.5	2.9	121.9
VIC	9.2	62.1	3.3	74.6	79.4	212.8	15.5	307.7
QLD [a]	5.7	0.4	-	6.1	61.9	2.0	0.2	64.0
SA	2.0	2.1	0.4	4.6	20.1	7.6	1.9	29.6
WA	3.8	8.1	0.4	12.3	24.9	22.0	1.9	48.7
TAS	0.8	0.4	0.6	1.8	6.9	1.4	3.0	11.3
NT	1.1	-	-	1.1	15.2	-	-	15.2
ACT	1.0	1.2	-	2.2	10.2	4.4	0.2	14.7
AUS	37.4	77.4	5.4	120.2	325.1	262.6	25.5	613.2

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[b] Resetting the energy performance benchmark for Class 2 dwellings in Queensland under Option B to be the same as all other states would reduce the energy saved by Class 2 dwellings in Queensland to 1.4 PJ in total, and reduce the present value of energy savings from $48.9 million to $16.3 million.

Note: Savings account for the rebound effect discussed in Chapter 5. Negative values represent increases in energy use/cost. Present values at 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

7.2.2 Change in generation investment

As discussed in Section 5.5.4, there are costs and benefits associated with the change in generation investment in Victoria associated with the NCC 2022. Table 7.10 outlines the estimated additional costs associated with the proposed changes to the NCC in present value terms over the modelled period. The impact is only in Victoria and only under Option A, with the more stringent requirements.

Table 7.10 Estimated change in generation investment, present value (2022-2060, $M 2021)

	Option A	Option B
VIC	-$351.2	$0.0
Australia	**-$351.2**	**$0.0**

Source: ACIL Allen.

7.2.3 Deferred network investment for gas and electricity

As outlined in Sections 5.5.4 and 5.5.5, two types of network benefits have been estimated in the analysis:

— benefits from deferred electricity network costs as a result of reductions in peak demand

— benefits from deferred gas pipeline costs as a result of reductions in gas use.

As noted in Section 6.2, there is a degree of fuel substitution in the modelled dwellings, which means that there are likely to be some offsetting effects between gas and electricity network investments. To take this effect into account we have modelled the impacts on both electricity and gas networks.

Consistent with the approach used to estimate energy savings at the economy-wide level, as new cohorts of dwellings are built, the network benefits (and energy savings) associated with the NCC 2022 increase, and then start to decrease in the future as the features installed to comply with the new code reach their end of life. Once investments reach the end of their life, the opposite effect occurs — energy savings (and their associated network benefits) fall. In this way, the net impact on the network is considered.

Table 7.11 outlines the estimated network benefits associated with the proposed changes to the NCC in present value terms over the modelled period.

Table 7.11 Estimated deferred network investment for gas and electricity, present value (2022-2060, $M 2021)

	Deferred electricity network costs	Deferred gas pipeline costs	Total
Option A			
NSW	$35.1	$2.5	$37.6
VIC	$14.8	$10.8	$25.6
QLD	$9.4	$0.1	$9.5
SA	$5.8	$0.4	$6.2
WA	$8.5	$1.4	$9.9
TAS	$2.2	$0.0	$2.2
NT	$3.6	$0.0	$3.6
ACT	$1.8	$0.3	$2.2
AUS	$81.3	$15.5	$96.8

	Deferred electricity network costs	Deferred gas pipeline costs	Total
Option B			
NSW	$15.7	$0.4	$16.1
VIC	$3.9	$6.3	$10.2
QLD	$4.4	$0.1	$4.5
SA	$2.6	$0.2	$2.8
WA	$5.9	$0.8	$6.8
TAS	$1.2	$0.0	$1.2
NT	$1.8	$0.0	$1.8
ACT	$2.3	$0.1	$2.5
AUS	$37.9	$7.9	$45.8

Note: Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Negative values represent increases in cost. Present values at 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

As shown in Table 7.11, broadly, total net network benefits nationally are estimated to be positive under both policy options. It is estimated that under Option A there would be net savings in both electricity and gas networks at a national level. In contrast, Option B is estimated to have a net increase in electricity network costs, but savings in gas network costs that are substantial enough to offset the increase in electricity network costs, resulting in a net benefit in total avoided network investment.

All jurisdictions are estimated to experience overall cost reductions in both electricity and gas networks.

7.2.4 Reduced GHG emissions

The reductions in energy consumption would result in a reduction in the associated GHG emissions. It is estimated that on average, the changes proposed under Option A would reduce emissions from the Australian new housing stock by around 16 Mt CO2-e over the period 2022-2060, and by around 7 Mt CO2-e under Option B (see Table 7.12). The estimated present value of these savings is around $701 million under Option A and approximately $279 million under Option B.

Table 7.12 Estimated cumulative impacts of proposed changes on GHG emissions (2022-2060)

	Emissions saved (million tonnes CO2-e)				Present value of GHG savings ($M, $2021)
	Electricity	Gas	LPG and Firewood	Total	
Option A					
Class 1					
NSW	1.99	0.16	0.003	2.15	115.03
VIC	3.62	4.86	0.016	8.50	330.33
QLD	0.90	0.01	0.000	0.90	45.14
SA	0.19	0.12	0.002	0.31	13.75
WA	0.67	0.45	0.002	1.12	50.33
TAS	0.01	0.02	0.003	0.04	1.59
NT	0.26	0.00	0.000	0.26	11.81
ACT	0.06	0.05	0.000	0.12	5.40
AUS	7.70	5.66	0.027	13.39	573.37
Class 2					
NSW	-0.03	0.93	0.000	0.90	43.04
VIC	-0.16	0.83	0.000	0.67	29.49
QLD [a]	0.72	0.02	0.000	0.73	36.14
SA	-0.00	0.07	0.000	0.07	3.09
WA	-0.03	0.20	0.000	0.18	8.03
TAS	0.00	0.00	0.000	0.00	0.10
NT	0.03	0.00	0.000	0.03	1.23
ACT	0.03	0.12	0.000	0.15	6.95
AUS	0.55	2.17	0.000	2.72	128.06
Total					
NSW	1.96	1.09	0.003	3.05	158.06
VIC	3.47	5.68	0.016	9.17	359.82
QLD	1.61	0.03	0.000	1.64	81.29
SA	0.19	0.19	0.002	0.38	16.84
WA	0.64	0.65	0.002	1.29	58.35
TAS	0.01	0.02	0.003	0.04	1.69
NT	0.29	0.00	0.000	0.29	13.04
ACT	0.09	0.17	0.000	0.26	12.35
AUS	8.25	7.83	0.027	16.12	701.43

	Emissions saved (million tonnes CO2-e)				Present value of GHG savings ($M, $2021)
	Electricity	Gas	LPG and Firewood	Total	
Option B					
Class 1					
NSW	0.44	0.15	0.003	0.59	29.64
VIC	0.87	3.30	0.016	4.19	153.17
QLD	0.15	0.01	0.000	0.15	7.08
SA	0.04	0.12	0.002	0.16	6.16
WA	0.21	0.42	0.002	0.63	25.23
TAS	0.00	0.02	0.003	0.03	0.97
NT	0.07	0.00	0.000	0.07	3.39
ACT	0.02	0.04	0.000	0.06	2.63
AUS	1.81	4.05	0.027	5.89	228.27
Class 2					
NSW	0.06	0.05	0.000	0.11	5.68
VIC	0.08	0.14	0.000	0.22	9.51
QLD [a, b]	0.54	0.02	0.000	0.56	28.10
SA	0.01	0.01	0.000	0.02	0.69
WA	0.03	0.04	0.000	0.07	2.91
TAS	0.00	0.00	0.000	0.00	0.03
NT	0.01	0.00	0.000	0.01	0.70
ACT	0.03	0.03	0.000	0.06	2.59
AUS	0.75	0.29	0.000	1.04	50.23
Total					
NSW	0.50	0.20	0.003	0.71	35.32
VIC	0.95	3.44	0.016	4.41	162.68
QLD	0.69	0.02	0.000	0.72	35.19
SA	0.04	0.13	0.002	0.18	6.85
WA	0.24	0.45	0.002	0.69	28.15
TAS	0.00	0.02	0.003	0.03	1.00
NT	0.09	0.00	0.000	0.09	4.10
ACT	0.05	0.07	0.000	0.12	5.21
AUS	2.57	4.34	0.027	6.94	278.50

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

	Emissions saved (million tonnes CO2-e)				Present value of GHG savings ($M, $2021)
	Electricity	Gas	LPG and Firewood	Total	

[b] Resetting the energy performance benchmark for Class 2 dwellings in Queensland under Option B to be the same as all other states would reduce the value of GHG savings in Class 2 dwellings in Queensland from $28.1 million to $9.05 million.

Note: Savings account for the rebound effect discussed in Chapter 5. Present values at 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

7.2.5 Health benefits from improved air quality

The mining and combustion of coal for electricity generation and the burning of gas (whether to generate electricity or for other purposes) produce air pollution which can cause health problems such as respiratory illness.

Based on the method described in Chapter 5, we estimated the health benefits associated with the improvement in air quality due to a reduction in electricity generated by gas and coal and with the reduction in gas and wood use. These are outlined in Table 7.13. As shown in this table, it is estimated that Option A would provide health benefits to the Australian economy worth around $205 million in present value terms, and Option B would deliver around $75 million in benefits.

Table 7.13 Estimated present value of health impacts over the period 2022-2060, $M ($2021)

	Benefits from reduced coal-powered electricity generation	Benefits from reduced gas-powered electricity generation	Benefits from reduced gas use	Benefits from reduced wood use	Total
Option A					
NSW	51.7	9.0	2.2	1.5	64.5
VIC	39.9	-7.3 [b]	9.6	8.1	50.3
QLD	46.0	6.0	0.1	0.1	52.2
SA	-	5.8	0.3	1.0	7.2
WA	16.2	10.2	1.3	1.0	28.6
TAS	-	-0.06 [b]	-	1.6	1.6
NT	-	0.3	-	-	0.3
ACT [a]	0.2	0.01	0.3	0.1	0.6
Australia	**154.0**	**24.0**	**13.8**	**13.3**	**205.1**
Option B					
NSW	15.5	2.7	0.3	1.5	20.0
VIC	11.7	-2.2 [b]	5.6	8.1	23.2
QLD	13.6	1.8	0.1	0.1	15.5

	Benefits from reduced coal-powered electricity generation	Benefits from reduced gas-powered electricity generation	Benefits from reduced gas use	Benefits from reduced wood use	Total
SA	-	1.74	0.2	1.0	2.9
WA	5.9	3.7	0.8	1.0	11.3
TAS	-	-0.02 [b]	-	1.6	1.6
NT	-	0.09	-	-	0.1
ACT [a]	0.1	-	0.1	0.1	0.3
Australia	**46.8**	**7.8**	**7.0**	**13.3**	**74.9**

[a] Notably, while these benefits are generated by reductions in energy consumption of ACT households, electricity used in the ACT is mainly generated in NSW. Hence, these benefits are not accrued to ACT household but to NSW households. However, these have been included in the modelling as an auxiliary benefit of reduced electricity use. Totals may not add up due to rounding.

[b] There is projected to be an increase in output from gas fired generation to provide dispatchable capacity to support the increase in variable renewable energy with the reduction in output from coal-fired generation.

Note: Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Accounting for the rebound effect discussed in Chapter 5. Present values at 7 per cent discount rate.

Source: ACIL Allen.

7.3 Net impacts on the economy

A summary of the quantified direct costs and benefits and the estimated net impact of the proposed changes on the Australian economy is provided in Table 7.14. Reflecting the level of certainty of different benefits discussed above, the NPV and BCR metrics are presented incrementally by adding benefits from the most certain to the least certain.

Table 7.14 indicates that, at an economy-wide level, both policy options appear to result in a net cost to society, even when including the somewhat more uncertain measures of benefit (the benefits from reduced carbon emissions and health benefits). This result is mainly driven by:

— valuing the benefits of reduced energy consumption using the resource cost (for which wholesale energy prices and avoided generation and network investment are used as a proxy), which as noted in Chapter 5, results in BCRs and NPVs that are much smaller than if retail energy prices were used

— the high capital costs for households associated with meeting the new targets.

Details of the costs and benefits for individual states and territories are presented in Appendix H.

Notably, relative to the CRIS:

— the construction costs for Option B (particularly for Class 2 dwellings) have significantly decreased
— the savings associated with electricity and gas use have significantly increased
— the greenhouse emissions savings and health benefits from the proposed changes have significantly increased
— it is estimated that Option A would result in increased generation and network investment for gas and electricity (this is mainly related to increased investment in generation in Victoria)
— the NPVs and BCRs of both options have significantly improved.

These improved results relative to the CRIS are the result of a number of changes in both the technical modelling and the economic modelling underpinning the RIS (summarised in Table ES.1 and further discussed in Chapter 5). Of particular significance to the results is the revised optimisation of expected design solutions undertaken by EES, which has resulted in lower compliance costs, higher benefits and improved benefit-cost ratios.

Table 7.14 Estimated lifetime (2022-2060) economy-wide costs and benefits of the proposed policy options, present value ($M, 2021), Australia

	Option A	Option B
COSTS		
Households - capital (resource) costs	3,579.6	1,285.3
Industry		
Training costs (incl. training time and training fees)	61.3	61.3
Redesign costs (volume builders)	31.7	31.7
Transition costs (custom builders)	107.3	107.3
Administrative costs (all buildings)	22.3	22.3
Government Costs	0.6	0.6
TOTAL COSTS	**3,802.8**	**1,508.5**
BENEFITS		
Households		
Electricity savings	978.2	325.1
Gas savings	515.3	262.6
LPG and firewood savings	25.5	25.5
Households offsetting amenity benefit [a]	122.7	59.0
Household subtotal	**1,641.7**	**672.1**

	Option A	Option B
Society		
Change in generation and network investment for gas and electricity	-254.4	45.8
Greenhouse emissions savings	701.4	278.5
Health benefits from reduced electricity generation and use of wood and gas	205.1	74.9
Society subtotal	**652.1**	**399.2**
TOTAL BENEFITS	**2,293.8**	**1,071.4**
NET PRESENT VALUES		
Accounting for energy benefits only	-2,415.5	-790.6
Accounting for energy benefits + carbon benefits	-1,714.1	-512.1
Accounting for energy benefits + carbon benefits + health benefits	-1,508.9	-437.2
BCR (RATIO)		
Accounting for energy benefits only	0.4	0.5
Accounting for energy benefits + carbon benefits	0.5	0.7
Accounting for energy benefits + carbon benefits + health benefits	0.6	0.7

[a] As discussed in Section 5.5.1, stakeholder feedback noted that the rebound effect included in the analysis represents an amenity benefit that is equal to or greater to the value of the energy saved. To reflect the value of this benefit, an offsetting 10 per cent amenity benefit to match the rebound effect has been included in the modelling.

Notes: Present values calculated using a 7 per cent discount rate. Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1). Totals may not add up due to rounding.

Source: ACIL Allen.

Table 7.15 provides estimates of the costs and benefits of the proposed changes for each dwelling class by option. Notably, the present values and BCRs in this table exclude industry and government costs (which are not class-specific). As shown in this table, Class 1 dwellings perform better under Option A and Class 2 dwellings perform better under Option B. This result is mainly driven by the impracticability of using solar PV in Class 2 dwellings, which results in having to use less cost effective solutions to meet the more stringent standards under Option A.

Table 7.16 shows the combined effect of using Option A for Class 1 dwellings and Option B for Class 2 dwellings. As show in this table, this combination of policies results in an improvement for the overall economy, with net costs reduced to $547 million and a BCR of 0.8.

Table 7.17 shows the estimated cumulative impacts of the combined option on energy savings and Table 7.18 shows its impact on GHG emissions. As shown Table 7.18 and Figure 7.2, the combination option delivers around twice the abatement of Option B and around 86 per cent of the abatement of Option A, but at a much lower cost to the overall economy.

Table 7.15 Estimated lifetime (2022-2060) economy-wide costs and benefits of the proposed policy options by class, present value ($M, 2021), Australia (excluding industry and government costs)

	Unit	Option A	Option B
CLASS 1			
Costs			
Capital (resource) costs	$M	2,140.9	1,016.4
Benefits			
Energy benefits [a, b]	$M	1,112.5	579.2
Greenhouse emissions savings	$M	573.4	228.3
Health benefits [b]	$M	172.7	46.8
Benefits minus cost [c]	$M	-282.4	-162.2
BCR [c]	Ratio	0.87	0.84
CLASS 2[d]			
Costs			
Capital (resource) costs	$M	1,438.7	268.9
Benefits			
Energy benefits [a, b]	$M	274.8	138.8
Greenhouse emissions savings	$M	128.1	50.2
Health benefits [b]	$M	32.4	28.2
Benefits minus cost [c]	$M	-1,003.3	-51.8 [e]
BCR [c]	Ratio	0.30	0.81 [e]

[a] Energy benefits include energy savings from all fuels, household offsetting amenity benefit and changes in generation and network investment for gas and electricity.

[b] Analysis by class assumes that health benefits and the benefits from changes in generation and network investment for gas and electricity are proportional to household energy savings.

[c] NPVs and BCRs by class exclude industry and government costs.

[d] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[e] Indicatively, resetting the energy performance benchmark in Queensland to be the same as all other states could decrease the net costs for Class 2 dwellings Australia-wide under Option B by around $10 million and decrease the BCR by around 3 per cent (to 0.78).

Notes: Present values calculated using a 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

Table 7.16 Estimated lifetime (2022-2060) economy-wide costs and benefits of applying Option A for Class 1 dwellings and Option B for Class 2 dwellings, present value ($M, 2021), Australia

COSTS		
Households - capital (resource) costs		2,333.0
Industry costs		222.6
Government Costs		0.6
	TOTAL COSTS	2,556.2
BENEFITS		
Households		
Energy benefits [a]		1,462.2
	Household subtotal	1,462.2
Society		
Change in generation and network investment for gas and electricity		-247.8
Greenhouse emissions savings		604.6
Health benefits from reduced electricity generation and use of wood and gas		190.3
	Society subtotal	547.0
	TOTAL BENEFITS	2,009.1
NET PRESENT VALUES		
Accounting for energy benefits only		-1,341.9
Accounting for energy benefits + carbon benefits		-737.4
Accounting for energy benefits + carbon benefits + health benefits		-547.1
BCR (RATIO)		
Accounting for energy benefits only		0.5
Accounting for energy benefits + carbon benefits		0.7
Accounting for energy benefits + carbon benefits + health benefits		0.8

[a] Energy benefits include energy savings from all fuels and household offsetting amenity benefit.

Notes: Present values calculated using a 7 per cent discount rate. Results reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). Totals may not add up due to rounding.

Source: ACIL Allen.

Table 7.17 Estimated impacts of the combined option on energy consumption (2022-2060)

	Energy saved (PJ)				Present value of energy savings ($M, $2021)			
	Electricity	Gas	LPG and Firewood	Total	Electricity	Gas	LPG and Firewood	Total
Class 1								
NSW	52.1	2.5	0.6	55.1	380.8	9.7	2.9	393.4
VIC	35.5	87.7	3.3	126.4	250.4	292.5	15.5	558.3
QLD	7.1	0.1	0.0	7.3	76.8	0.7	0.2	77.6
SA	7.7	1.9	0.4	10.1	64.8	7.2	1.9	73.9
WA	11.0	8.1	0.4	19.4	66.2	22.5	1.9	90.5
TAS	2.4	0.4	0.6	3.4	20.7	1.5	3.0	25.2
NT	3.1	0.0	0.0	3.1	44.0	0.0	0.0	44.0
ACT	1.6	0.8	0.0	2.4	12.8	3.0	0.2	15.9
AUS	120.4	101.5	5.4	227.3	916.4	337.0	25.5	1,278.9
Class 2								
NSW	1.8	0.8	0.0	2.6	16.7	4.2	0.0	20.9
VIC	1.1	2.5	-	3.6	11.1	11.3	-	22.4
QLD [a]	1.4	0.0	-	1.4	16.2	0.1	-	16.3
SA	0.2	0.2	-	0.4	2.4	0.7	-	3.1
WA	0.4	0.7	-	1.1	3.2	2.0	-	5.2
TAS	0.0	0.0	-	0.1	0.5	0.0	-	0.5
NT	0.1	0.0	-	0.1	2.4	0.0	-	2.4
ACT	0.5	0.5	-	1.0	6.0	1.8	-	7.8
AUS	5.6	4.7	0.0	10.3	58.4	20.1	0.0	78.5
Total								
NSW	53.8	3.3	0.6	57.7	397.5	13.9	2.9	414.3
VIC	36.6	90.2	3.3	130.1	261.5	303.7	15.5	580.7
QLD [a]	8.5	0.2	0.0	8.7	92.9	0.8	0.2	93.9
SA	7.9	2.1	0.4	10.4	67.2	7.9	1.9	77.0
WA	11.4	8.7	0.4	20.5	69.4	24.5	1.9	95.7
TAS	2.5	0.4	0.6	3.5	21.2	1.5	3.0	25.7
NT	3.2	0.0	0.0	3.2	46.4	0.0	0.0	46.4
ACT	2.1	1.2	0.0	3.4	18.7	4.8	0.2	23.7
AUS	126.0	106.1	5.4	237.5	974.8	357.1	25.5	1,357.4

[a] Results reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).

Note: Savings account for the rebound effect discussed in Chapter 5. Present values at 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

Table 7.18 Estimated cumulative impacts of the combined option on GHG emissions (2022-2060)

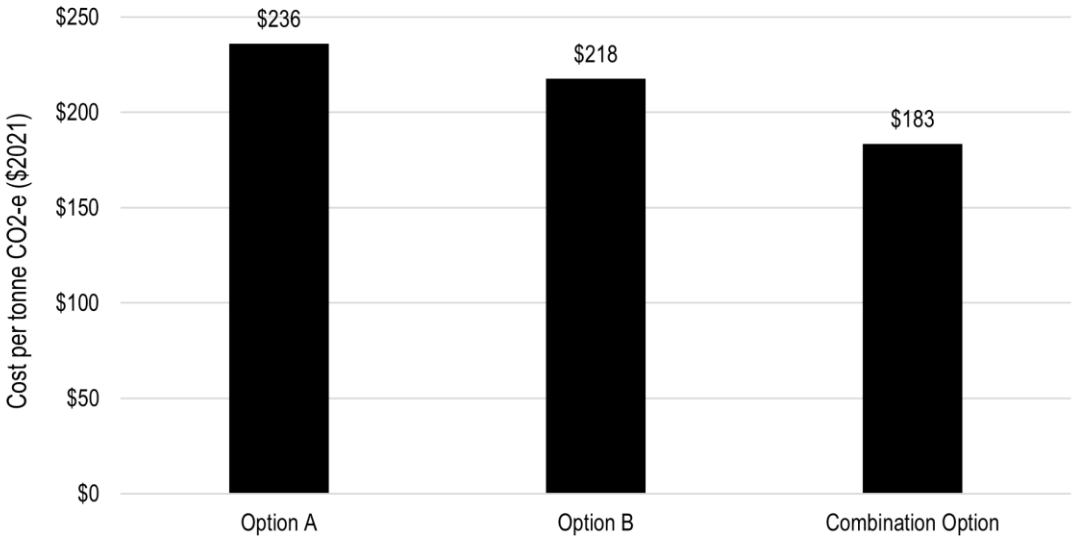
	Emissions saved (million tonnes CO2-e)				Present value of GHG savings ($M, $2021)
	Electricity	Gas	LPG and Firewood	Total	
Class 1					
NSW	1.99	0.16	0.003	2.15	115.03
VIC	3.62	4.86	0.016	8.50	330.33
QLD	0.90	0.01	0.000	0.90	45.14
SA	0.19	0.12	0.002	0.31	13.75
WA	0.67	0.45	0.002	1.12	50.33
TAS	0.01	0.02	0.003	0.04	1.59
NT	0.26	0.00	0.000	0.26	11.81
ACT	0.06	0.05	0.000	0.12	5.40
AUS	7.70	5.66	0.027	13.39	573.37
Class 2					
NSW	0.06	0.05	0.000	0.11	5.68
VIC	0.08	0.14	0.000	0.22	9.51
QLD [a]	0.18	0.00	0.000	0.18	9.05
SA	0.01	0.01	0.000	0.02	0.69
WA	0.03	0.04	0.000	0.07	2.91
TAS	0.00	0.00	0.000	0.00	0.03
NT	0.01	0.00	0.000	0.01	0.70
ACT	0.03	0.03	0.000	0.06	2.59
AUS	0.39	0.27	0.000	0.66	31.18
Total					
NSW	2.05	0.21	0.003	2.26	120.71
VIC	3.70	5.00	0.016	8.71	339.85
QLD	1.08	0.01	0.000	1.09	54.19
SA	0.19	0.13	0.002	0.33	14.45
WA	0.70	0.48	0.002	1.18	53.24
TAS	0.01	0.02	0.003	0.04	1.62
NT	0.28	0.00	0.000	0.28	12.51
ACT	0.09	0.08	0.000	0.17	7.99
AUS	8.09	5.94	0.027	14.06	604.55

[a] Results reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).

Note: Savings account for the rebound effect discussed in Chapter 5. Present values at 7 per cent discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

Figure 7.2 Cost per tonne of abatement ($/tonne CO2-e, $2021) under different policy options



Notes: Costs are in present values calculated using a 7 per cent discount rate. Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the combination option reflect the resetting of the energy performance benchmark to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).
Source: ACIL Allen

7.3.1 Regulatory burden

The OBPR's Guide to Regulatory Impact Analysis discusses the importance of avoiding imposing unnecessary regulatory burden on businesses, individuals and community organisations. Under OBPR's requirements, the regulatory burden of a policy proposal on businesses should be measured using the Regulatory Burden Measure (RBM) framework.

The framework includes consideration of the following regulatory costs[240]:

- compliance costs, including:
  - administrative costs
  - substantive compliance costs
- delay costs.

The costs associated with the proposed changes to the NCC that fall under the RBM framework are:

- the incremental costs associated with meeting the new energy efficiency requirements incurred by households
- the costs incurred by industry (including training costs, redesign costs for volume builders, transition costs for custom builders and administrative costs).

[240] Commonwealth of Australia, Department of the Prime Minister and Cabinet 2020, *Regulatory Burden Measurement Framework*, March.

Table 7.19 provides the regulatory burden estimate for each of the options in the RIS. As required by the OBPR, these costs are presented as average annual impacts (undiscounted) costed over the 10-year default duration of the regulation. As shown in this table, the average additional regulatory burden from the proposed changes to the NCC is:

— around $516 million per year for Option A. The Commonwealth's share of this regulatory burden is $57.3 million or 1/9th of the regulatory burden
— around $199 million per year for Option B. The Commonwealth's share of this regulatory burden is $22.1 million
— around $345 million per year for the combination option. The Commonwealth's share of this regulatory burden is $38.4 million.

Table 7.19 Regulatory burden estimate — average annual regulatory costs (from business as usual), $M 2021

	Business	Individuals	Total change in costs	Commonwealth's share of costs
Option A	24.0	492.1	516.1	57.3
Option B	24.0	174.6	198.7	22.1
Combination Option (Option A for Class 1 and Option B for Class 2)	24.0	321.2	345.3	38.4

Note: Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the Combination Option reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1).
Source: ACIL Allen.

7.4 Sensitivity and breakeven analysis

7.4.1 Sensitivity analysis

A sensitivity analysis was conducted to address five areas of uncertainty. For each of these areas, the analysis was conducted as follows:

— discount rate — a low discount rate of 3 per cent and a high discount rate of 10 per cent were tested. In addition, consistent with recent advice from best practice regulation guide, we have also tested the impact of decreasing the central discount rate from 7 per cent to 5.4 per cent after 30 years
— industry costs — an increase in industry costs of 50 per cent and a decrease in industry costs of 50 per cent were tested
— construction costs — in response to feedback from HIA, an increase in industry costs of 15 per cent and a decrease in industry costs of 15 per cent were tested
— carbon prices — we tested a decrease in carbon prices of 50 per cent and two increase scenarios, where carbon prices are two times the price used in the central case and the case where a higher carbon price is assumed (equal to the SCC value for the 95th percentile of the

frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate).

— energy savings achieved in practice — a medium realisation scenario where 75 per cent of the modelled energy savings are achieved in practice and a low realisation scenario where only 50 per cent of the savings are achieved in practice.

The results of the sensitivity analysis are provided in Table 7.20. This table shows that:

— Higher discount rates produce a more negative result (in this case, a higher net cost to society) and a lower (3 per cent) discount rate produces a lower net cost to society under Option A and a positive NPV for Option B and the Combined Option. Decreasing the central discount rate to 5.4 per cent after 30 years still results in net costs under all options.
— If industry costs are decreased or increased by 50 per cent, the NPV for the policy options change:
  – from -$1.51 billion under the initial ‘standard’ assumptions for Option A, to -$1.40 billion (when costs are decreased by 50 per cent) or -$1.62 billion (when costs are increased by 50 per cent). This is a potential change in the net impact of the scenario of around 7 per cent
  – from -$437 million under the initial ‘standard’ assumptions for Option B, to -$326 million or -$548 million (a potential change in the net impact of the scenario of around 25 per cent)
  – from -$547 million under the initial ‘standard’ assumptions for the combination option, to -$436 million or -$658 million (a potential change in the net impact of the scenario of around 20 per cent).
— If industry costs are decreased or increased by 15 per cent, the NPV for the policy options change:
  – from -$1.51 billion under the initial ‘standard’ assumptions for Option A, to -$972 million or -$2.05 billion (a potential change in the net impact of the scenario of around 36 per cent)
  – from -$437 million under the initial ‘standard’ assumptions for Option B, to -$244 million or -$548 million (a potential change in the net impact of the scenario of around 44 per cent)
  – from -$547 million under the initial ‘standard’ assumptions for the combination option, to -$197 million or -$897 million (a potential change in the net impact of the scenario of around 64 per cent).
— If carbon prices decrease by 50 per cent, the NPV for Option A decreases by around 23 per cent, from -$1.51 billion to -$1.86 billion, the NPV for Option B decreases by 32 per cent, from -$437 million to -$576 million and the NPV for the combination option decreases by 55 per cent, from -$547 million to -$849 million.
— If carbon prices increase by 100 per cent (i.e. if they double), the NPV for Option A improves by 46.5 per cent, from -$1.51 billion to -$0.81 billion, the NPV for Option B improves by 64 per cent, from -$437 million to -$159 million and the NPV for the combination option becomes positive and results in net benefits of $57 million.

- If the SCC value for the 95th percentile of the frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate is used, the NPV for Option A improves by around 95 per cent, from -$1.51 billion to -$83 million, the NPV for Option B becomes positive, improving from -$437 million to $130 million and the NPV for the combination option also becomes positive, improving from -$547 million to $682 million.
- Under a medium realisation scenario (where 75 per cent of the modelled energy savings are achieved) the net losses under Option A would increase by 23 per cent from -$1.51 billion to -$1.9 billion, the net losses under Option B would increase by 40 per cent from -$437 million to -$612 million and the net losses under the combination option would increase by around 55 per cent, from -$547 million to -$846 million.
- Under a low realisation scenario (where only 50 per cent of the modelled energy savings are achieved) the net losses under Option A would increase by 60 per cent from -$1.51 billion to -$2.42 billion, the net losses under Option B would increase by more than 100 per cent from -$437 million to -$888 million and the net losses under the combination option would more than double from -$547 million to -$1.3 billion.

This analysis shows that substantial changes to most of the assumptions are not sufficient to result in a BCR of one (or a positive net present value), except for:

- Option B under the case where:
  - a 3 per cent discount rate is used
  - a higher carbon price is assumed (equal to the SCC value for the 95th percentile of the frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate).
- The Combined Option under the case where:
  - a 3 per cent discount rate is used
  - a higher carbon price is assumed – either doubled or set equal to the SCC value for the 95th percentile of the frequency distribution of the future costs of climate change discounted at a 3 per cent discount rate.

Table 7.20 Sensitivity analysis — impact of sensitivity tests on the NPV under each policy option ($M, 2021)

	Option A	Option B	Option A for Class 1 + Option B for Class 2
NPV under standard assumptions	-$1,509	-$437	-$547
Discount rate			
Decrease from 7% to 3%	-$542	$33	$493
Increase from 7% to 10%	-$1,792	-$585	-$896
7% from year 1 to 30 and 5.4% from year 31 onwards [a]	-$1,487	-$423	-$526
Industry costs [b]			
Decrease costs by 50%	-$1,398	-$326	-$436
Increase costs by 50%	-$1,620	-$548	-$658
Construction costs [b]			
Decrease costs by 15%	-$972	-$244	-$197
Increase costs by 15%	-$2,046	-$630	-$897
Carbon price [b]			
Decrease price by 50%	-$1,860	-$576	-$849
Increase price by 100%	-$808	-$159	$57
SCC at 95% percentile, 3% discount rate	-$83	$130	$682
Performance gap			
Low realisation scenario — 50% of modelled energy savings are achieved in practice	-$2,419	-$888	-$1,315
Medium realisation scenario — 75% of modelled energy savings are achieved in practice	-$1,863	-$612	-$846

[a] The OBPR has recently updated their guidance for incorporating environmental impacts and uncertainty into regulatory impact analysis. In this guidance, the OBPR notes that for analyses involving very long timeframes, uncertainty about the 'true' discount rate means that it is appropriate to use a time declining discount rate. In particular, it is recommended that for analyses involving a period of analysis of between 31 and 75 years, the central discount rate declines from 7 per cent to 5.4 per cent after 30 years.

[b] Changes are modelled as level changes applied evenly for all years, all building classifications, and all jurisdictions and climate zones (i.e. not year on year change).

Note: Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the combination option reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). All changes are modelled as changes from the central case scenario (which includes a rebound effect of 10 per cent). Totals may not add up due to rounding.

Source: ACIL Allen.

7.4.2 Breakeven analysis

Breakeven analyses are common practice in situations where the degree of benefit associated with a proposal is uncertain. It involves a simulation process where key parameters of the model – in this case, the energy prices and the costs of the upgrades – are varied until the net impacts calculated through the model equal zero. In other words, it answers the questions:

— how much would the wholesale energy prices have to increase for the proposed policy options to break even to society in cost-benefit terms?

— how much would the upgrade costs have to decrease for the proposed policy options to break even to society in cost-benefit terms?

This breakeven analysis is similar to the sensitivity analysis outlined above only the parameters are varied to achieve a particular outcome. In this case, the parameters are varied until:

1. the NPV in each jurisdiction equals at least zero and the BCR at least equals one
2. the national NPV is equal to zero and the BCR is one.

The results of the breakeven analysis are provided in Table 7.21. As shown in this table, for the energy efficiency requirements in the NCC 2022 to:

— at least breakeven in each jurisdiction
  – the wholesale energy prices would need to be around 2.5 times higher under Option A, around 2.8 higher under Option B and around double under the combination option
  – the costs of upgrades would need to be between halt and 62 per cent of the current costs

— breakeven nationally
  – the wholesale energy prices would need to be almost two times higher than the projected prices used in the central case scenario (i.e. two times higher than the prices shown in Figure 5.13 and Figure 5.14 which already project a substantial increase over time) under Option A, and between 37 per cent and 65 per cent higher under the combination option and Option B, respectively
  – the costs of upgrades would need to be between 23 per cent and 42 per cent of the current costs.

Table 7.21 Breakeven analysis [a]

	Option A	Option B	Option A for Class 1 + Option B for Class 2
Breakeven in each jurisdiction			
Percentage change in wholesale energy prices to breakeven	151%	183%	108%
Percentage change in capital costs to breakeven	-50%	-62%	-50%

	Option A	Option B	Option A for Class 1 + Option B for Class 2
Breakeven nationally			
Percentage change in wholesale energy prices to breakeven	92%	65%	37%
Percentage change in capital costs to breakeven	-42%	-34%	-23%

[a] Breakeven point is where the benefits of the policy option minus its costs equal zero (in net present value terms), with a 7 per cent discount rate.

Note: Results for Option A and B reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and results for the Combination Option reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). All changes are modelled as level changes applied evenly for all years, all building classifications, and all jurisdictions and climate zones (i.e. not year on year change). Totals may not add up due to rounding.

Source: ACIL Allen.

7.5 Energy market impacts

Concerns have been raised regarding the impact of the increased uptake of solar PV on the wholesale energy market (and the network). As a consequence, wholesale energy market modelling using our proprietary model, *PowerMark*, has been undertaken to project:

- the change in wholesale electricity prices in the National Electricity Market (NEM) and the South West Interconnected System (SWIS) in Western Australia
- any changes in capacity in terms of new investments or retirements of existing generators
- changes in minimum demand levels.

The impact of the increased uptake of solar PV on the electricity grid is discussed in section 9.6.4.

7.5.1 Scenarios modelled

Three scenarios have been modelled:

1. Reference case – which is ACIL Allen’s standard reference case as at March 2021.
2. Scenario 1 – which includes the changes in energy consumption, peak demand and solar PV installations as estimated to meet the more stringent of the two proposed options for NCC 2022 for Class 1 buildings (Option A) and the less stringent of the two proposed options for Class 2 buildings (Option B).
3. Scenario 2 – which is the same as scenario 1 other than it includes twice as much solar PV installation capacity as scenario 1, to reflect the experience gained over the last ten years that many home owners will install more PV capacity than economically justified.

7.5.2 Assumptions

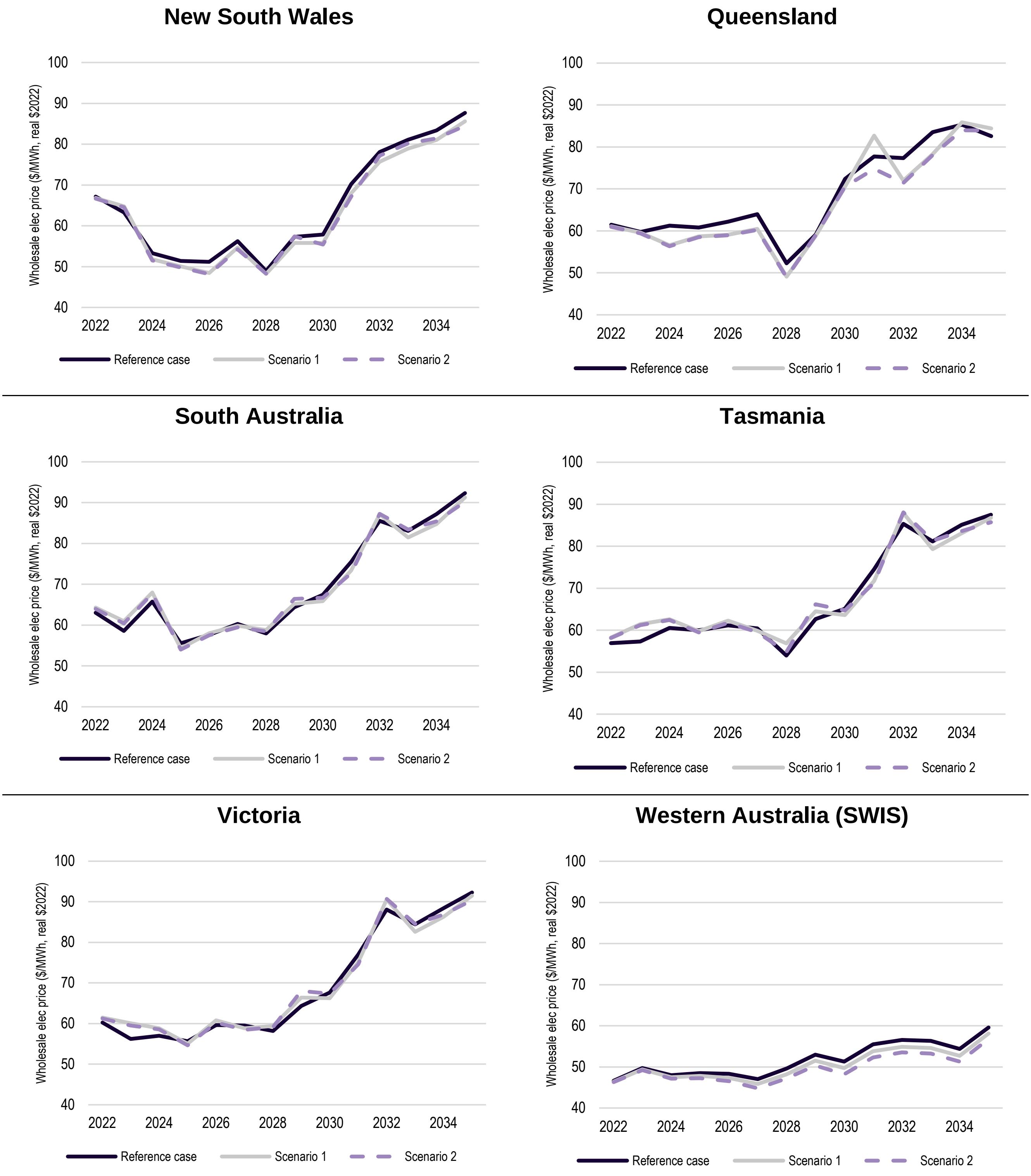
The assumptions that have been used in the wholesale electricity market modelling are provided in Appendices J and K.

7.5.3 Impacts on wholesale electricity prices

The wholesale energy market modelling projects that the time weighted wholesale electricity price is projected to be between 8 per cent lower and 8 per cent higher under the proposed NCC 2022 (scenario 1) than under the reference case, as illustrated in Figure 7.3. There is downward pressure on the wholesale electricity price with a reduction in the energy consumed from the network, and upward pressure with an increase in peak demand.

There is a relatively small difference in the wholesale electricity prices between scenarios 1 and 2, other than in 2031 in Queensland, which is due to the timing of new investment.

Figure 7.3 Projected time weighted wholesale electricity prices, 2022 to 2035



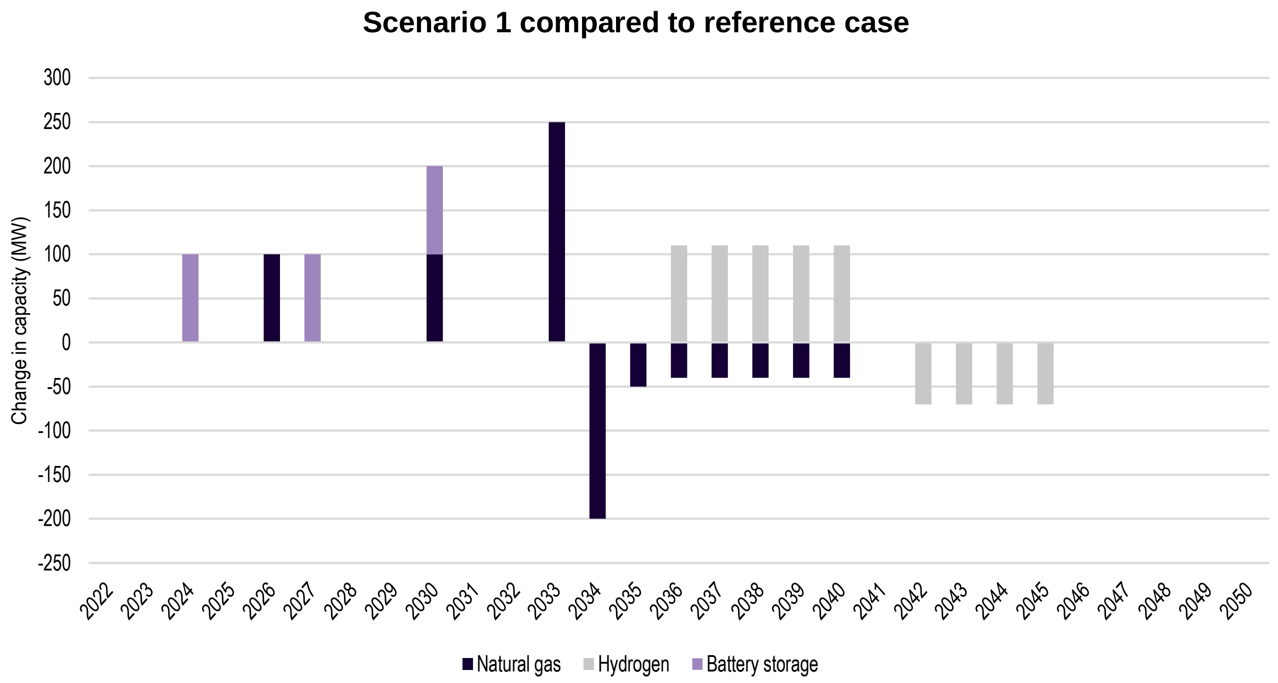
Source: ACIL Allen

In aggregate, the changes in wholesale electricity prices under scenario 1 are projected to result in an increase in electricity costs for consumers of $1.9 billion using a 7 per cent discount rate, which represents a 0.6 per cent increase in wholesale electricity costs.[241] This is a distributional effect rather than a net societal cost, as the additional costs for consumers are additional revenues for generators. The change in net societal costs (the change in resource costs and investment in new capacity) is included in the cost benefit analysis.

7.5.4 Impact on generator capacity and output

The wholesale energy market modelling does not project any change in generator capacity with the proposed NCC 2022, other than in Victoria. The proposed NCC 2022 brings forward investment in battery storage and gas-fired generation in Victoria, and the conversion of gas-fired generation to hydrogen-fired generation, as illustrated in Figure 7.3. The cost associated with bringing forward investment in generation capacity is included as a societal cost in the cost benefit analysis.

Figure 7.4 Change in generator capacity in Victoria, 2022 to 2050



Source: ACIL Allen

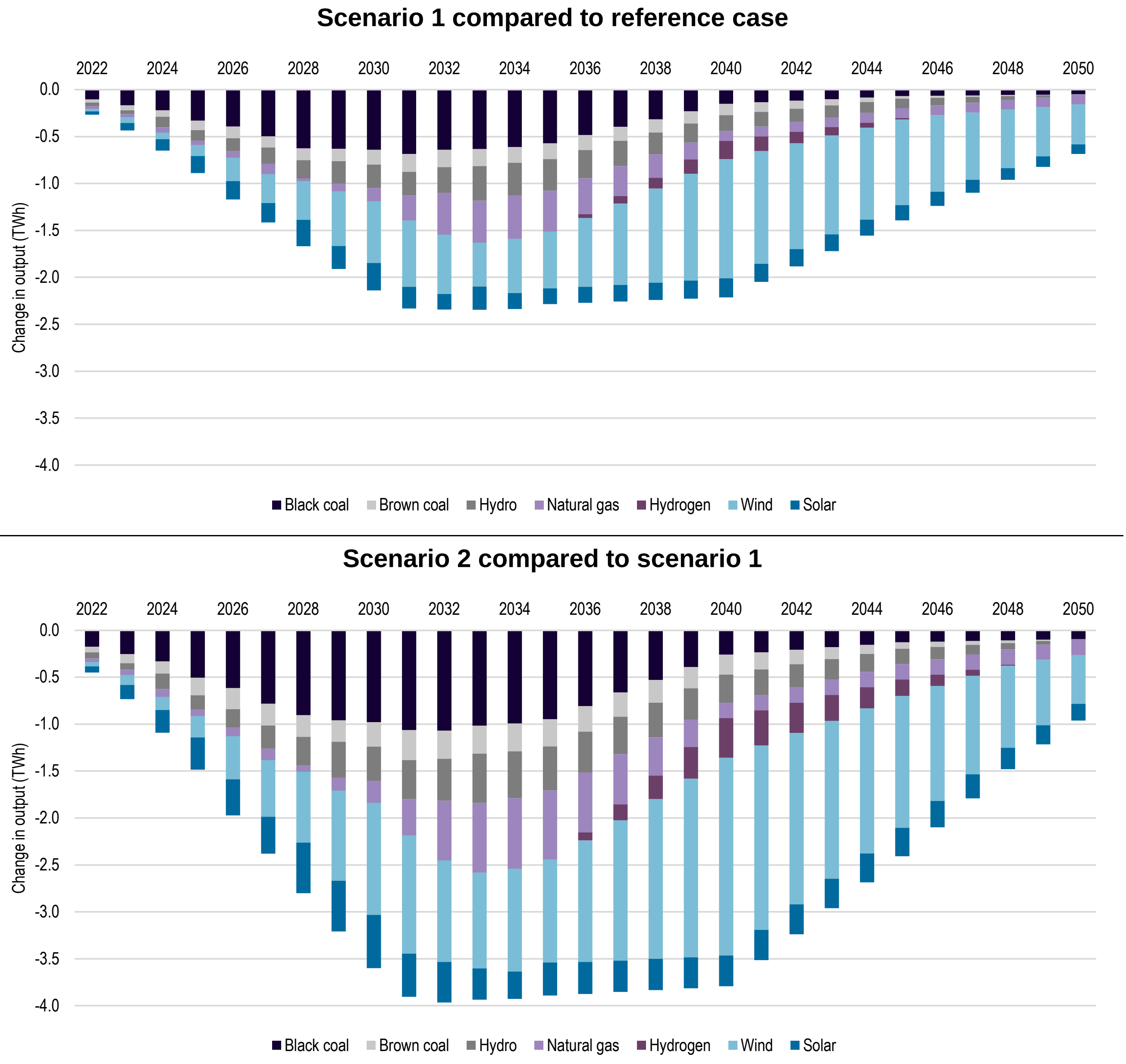
The projected change in generator output across the NEM and the SWIS from 2022 to 2050 is illustrated in Figure 7.5 – the top pane illustrates the change in output from the reference case to scenario 1 and the bottom pane illustrates the change in output from the reference case to scenario 2.

Figure 7.5 shows that there is a reduction in output from black coal generators, brown coal generators, gas-fired generators, hydro generators, wind and solar. The decline in output increases from 2021 to 2032, and then the decline in output reduces from 2040. From 2036, there is a reduction

[241] Wholesale electricity costs represent between 25 and 40 per cent of the retail electricity bill. The increase in retail electricity costs is therefore between 0.2 and 0.3 per cent.

in output from hydrogen-fired generators. To put these reductions in perspective, the maximum reduction in generator output is 0.93 per cent in 2031 between the reference case and scenario 1 and 1.55 per cent in 2031 between the reference case and scenario 2.

Figure 7.5 Projected change in generator output across the NEM and SWIS, 2022 to 2050



Source: ACIL Allen

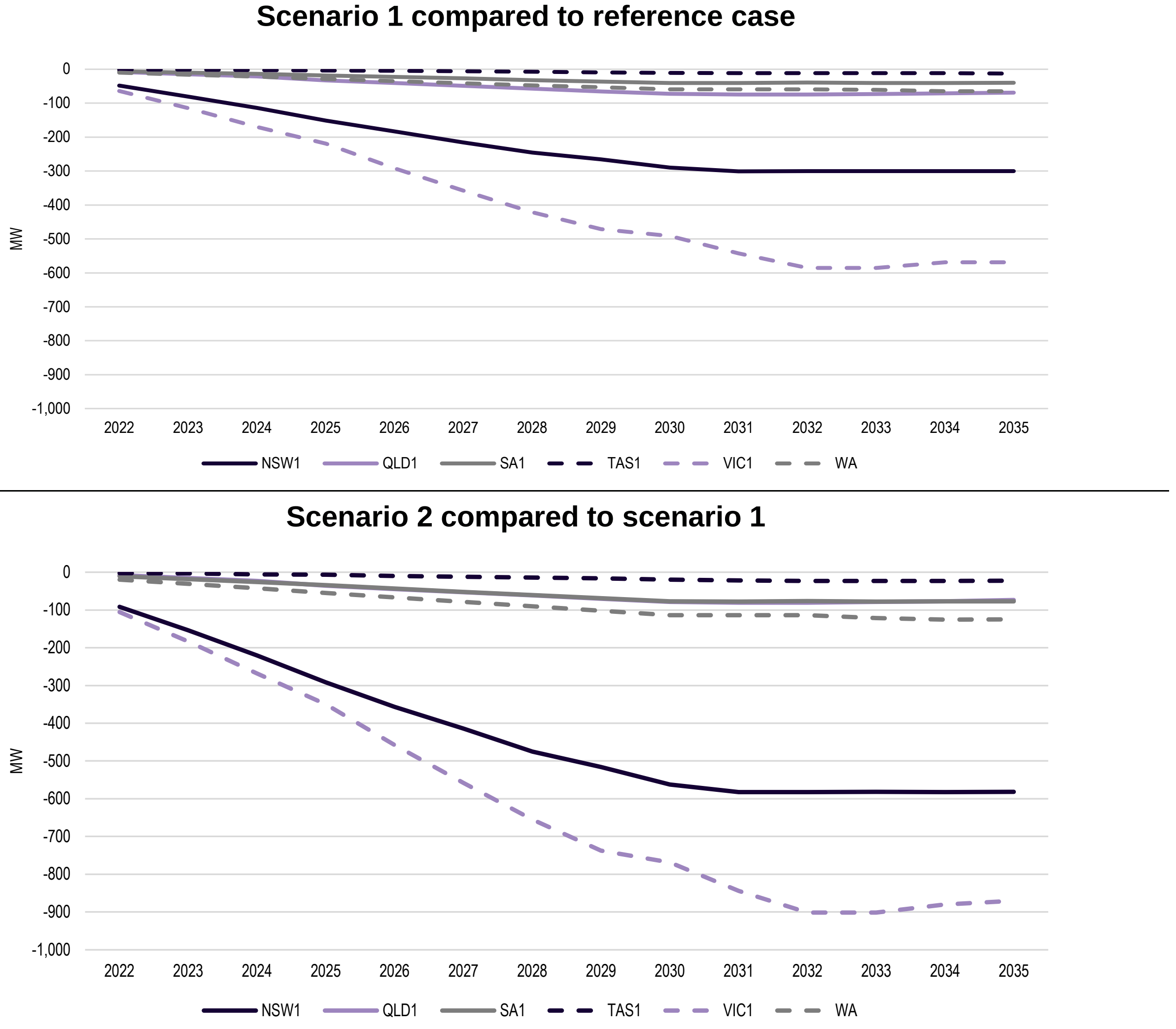
The reduction in output from wind and solar from the reference case to scenarios 1 and 2 is due to curtailment when wholesale electricity prices are negative. There are more periods of negative wholesale electricity process when there is more rooftop solar PV installed under scenarios 1 and 2.

7.5.5 Minimum demand levels

As the minimum demand level on the electricity supply system decreases, there are increasing challenges in maintaining the security and reliability of the electricity supply system.[242] The projected change in minimum demand levels in the NEM jurisdictions as a result of the proposed NCC 2022 is illustrated in Figure 7.6 – the top pane illustrates the difference in the minimum demand levels between the reference case and scenario 1 and the bottom pane illustrates the difference in the minimum demand levels between the reference case and scenario 2 (with twice as much solar PV capacity as scenario 1).

The projected change in the minimum demand levels is immaterial in Tasmania, South Australia, Queensland and Western Australia, more material in New South Wales, and the most material in Victoria.

Figure 7.6 Projected change in minimum demand levels, 2022 to 2050



Source: ACIL Allen

242 The challenges include voltage management, unintended disconnection of distributed solar, ability to meet minimum demand thresholds, ability to manage severe disturbances on the system and ability to restart the system after a major blackout.

The projected minimum demand levels are positive, that is, the net load on the system is greater than zero[243], in all years in New South Wales, Queensland and Tasmania.

The projected minimum demand level in South Australia is negative, that is, the net load on the system is less than zero[244], from 2022 under the reference case and scenarios 1 and 2. The date by when the projected minimum demand level is negative is brought forward under scenarios 1 and 2 relative to the reference case in Victoria (from 2042 to 2028 and 2029) and Western Australia (from 2034 to 2032 and 2030).

The load duration curve for Victoria in 2040, based on hourly data, is provided in Figure 7.7 and Figure 7.8. Figure 7.7 provides the load duration curve across the entire year and Figure 7.8 amplifies the load duration curve when the load is in the lowest 5 percentile. The load duration curve illustrates the period of time when load is above a certain level. For example, under the reference case, the minimum load is never above 13,287 MW, 50 per cent of the time, the load is above 8,078 MW and 95 per cent of the time, the load is above 3,742 MW.

In 2040, the minimum demand in Victoria is projected to be:

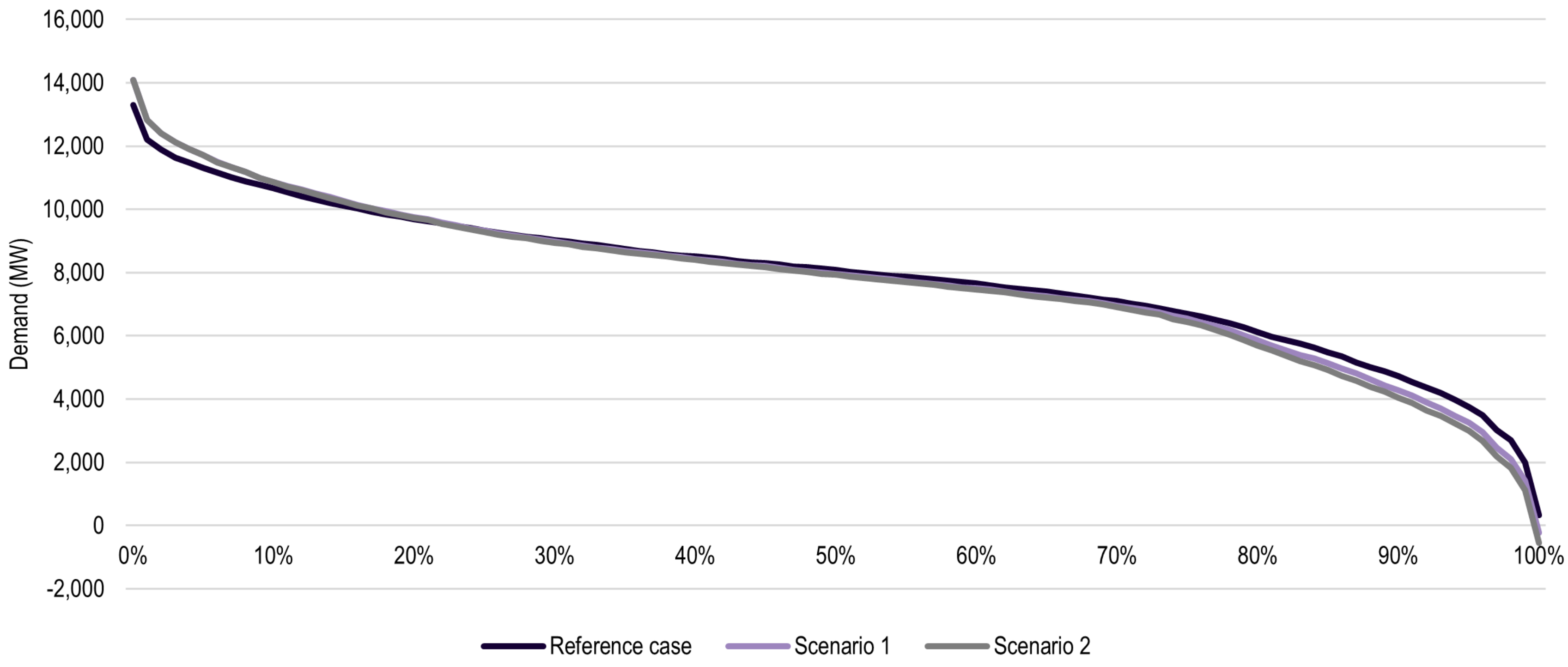
— 322 MW under the reference case
— -226 MW under scenario 1
— -542 MW under scenario 2.

Under scenario 1, the minimum demand is projected to be negative for around 0.114 per cent of the year or 10 hours. Under scenario 2, the minimum demand is projected to be negative for around 0.198 per cent of the year, or 17 hours.

[243] The load on the system exceeds the output from variable renewable energy generators.

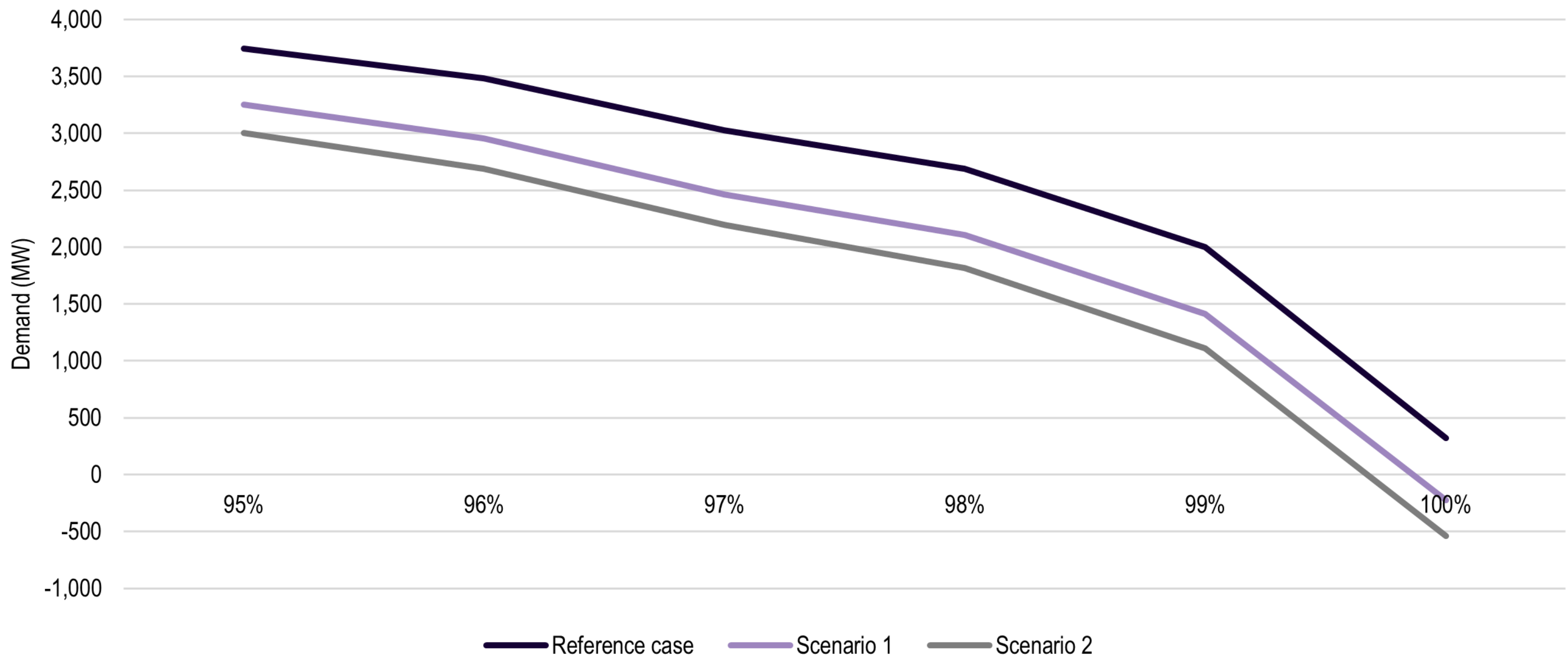
[244] The output from variable renewable energy generators exceeds the load on the system.

Figure 7.7 Load duration curve over the entire year, Victoria, 2040



Source: ACIL Allen.

Figure 7.8 Load duration curve, lowest 5 percentile, Victoria, 2040



Source: ACIL Allen.

8 Impact on households

This chapter analyses the impacts of the proposed changes to the energy efficiency requirements in the NCC from the perspective of the individual households affected by the changes. In particular, it analyses the net impacts of the changes on energy bills and on housing affordability for homebuyers across different states and territories.

8.1 Distributional impacts

As is standard practice, the CBA of the proposed changes to the NCC was undertaken from the perspective of the broader Australian community, with impacts that are transfers between stakeholders (such as between the government and households, and between households that are subject to the proposed changes and those that are not) netted out. Nevertheless, it is important to consider the implications of some of these transfers on stakeholders, particularly the implications of energy bill reductions on households.

Table 8.1 shows the estimated energy bill savings for an average household in each state residing in the dwellings that are modelled to have implemented the proposed NCC changes, compared to the total costs of the upgrades/changes (in present value terms). The effect on these households is measured using retail energy costs, rather than wholesale energy costs and changes in generation and network investment, which leave them better off, over and above the reduced resource cost. The difference between the reduction in retail energy costs and the reduction in wholesale energy costs and avoided network investment is, in reality, transferred to others in the community.

The estimated impacts in Table 8.1 show that all Class 1 dwellings under Option A and all Class 2 dwellings under Option B (except those in Queensland) are estimated to experience net benefits from the proposed change (that is, the benefits received by households in these dwellings from the additional energy efficiency measures installed are more than sufficient to cover the additional costs incurred to implement these measures). This table also shows that:

- Under Option A, the proposed changes are estimated to result in net costs for most households in Class 2 dwellings across Australia, except for households in Class 2 dwellings in Tasmania and the ACT who are estimated to experience net benefits from the proposed changes.
- Under Option B, the proposed changes are estimated to result in net costs for households in Class 1 dwellings in Queensland and Tasmania.

This analysis shows that applying Option A for Class 1 dwellings and Option B for Class 2 dwellings results in net benefits to households in all jurisdictions except for households in apartments in Queensland.

Table 8.2 shows the estimated average energy savings for a new building in the first year of the regulations (2022). As shown in this table, households in Class 2 dwellings in some jurisdictions would experience some fuel switching (and hence increases in electricity bills) after the NCC changes are implemented, but overall, all households across all jurisdictions would experience energy bill reductions under both policy options.

Notably, as outlined in Section 5.3.3, the results of the distributional analysis in Table 8.1 and Table 8.2 include the costs and benefits of thermal bridging mitigation.

Table 8.1 Estimated lifetime (2022- 2051) distributional impacts for dwellings built in 2022, $ per household, (present value, $2021)

	Capital costs ($)	Energy bill savings ($)	Other benefits ($)	Net impact ($,NPV)	Household BCR
Option A					
Class 1					
NSW	3,319	3,832	347	859	1.26
VIC	3,310	4,263	394	1,347	1.41
QLD	710	790	86	166	1.23
SA	1,808	2,472	253	916	1.51
WA	1,020	1,660	163	803	1.79
TAS	3,135	2,984	310	160	1.05
NT	6,762	6,876	599	712	1.11
ACT	1,243	2,262	234	1,253	2.01
Australia	2,199	2,761	261	822	1.37
Class 2					
NSW	4,279	1,904	212	-2,163	0.49
VIC	4,656	1,692	188	-2,776	0.40
QLD [a]	5,004	2,690	299	-2,015	0.60
SA	3,410	2,687	299	-425	0.88
WA	2,869	1,730	192	-947	0.67
TAS	2,106	3,232	359	1,485	1.71
NT	4,828	3,837	426	-565	0.88
ACT	2,889	2,797	311	219	1.08
Australia [a]	4,283	2,062	229	-1,992	0.53

	Capital costs ($)	Energy bill savings ($)	Other benefits ($)	Net impact ($,NPV)	Household BCR
Option B					
Class 1					
NSW	1,119	1,048	100	29	1.03
VIC	1,870	2,386	249	765	1.41
QLD	356	145	15	-196	0.45
SA	846	1,030	112	296	1.35
WA	609	922	98	411	1.68
TAS	1,833	1,319	143	-370	0.80
NT	2,605	2,635	261	291	1.11
ACT	600	1,065	116	580	1.97
Australia	1,059	1,203	124	268	1.25
Class 2					
NSW	534	518	58	41	1.08
VIC	542	587	65	110	1.20
QLD [b]	764	655	73	-36	0.95
SA	585	1,230	137	782	2.34
WA	251	913	101	764	4.04
TAS	1,005	2,060	229	1,284	2.28
NT	1,271	1,936	215	880	1.69
ACT	844	1,307	145	608	1.72
Australia [b]	579	670	74	166	1.29

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[b] Results reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions).

Notes: estimates use retail energy prices and refer to dwellings built in 2022. Present values calculated using a 7% discount rate. Totals may not add up due to rounding.

Source: ACIL Allen.

Table 8.2 Estimated average energy savings per household in 2022 by fuel ($2021)

	Electricity	Gas	LPG & firewood	Total
Option A				
Class 1				
NSW	313	12	1	326
VIC	134	185	6	324
QLD	82	1	0	83
SA	172	32	3	206
WA	100	43	1	144
TAS	235	25	16	276
NT	594	0	0	594
ACT	168	43	1	212
Australia	161	65	3	229
Class 2				
NSW	-23	215	0	193
VIC	-72	229	0	157
QLD [a]	271	14	0	284
SA	-34	311	0	277
WA	-64	242	0	177
TAS	242	103	0	344
NT	344	8	0	352
ACT	116	176	0	292
Australia	25	183	0	208
Option B				
Class 1				
NSW	75	9	1	86
VIC	48	131	6	185
QLD	9	1	0	10
SA	49	28	3	80
WA	42	36	1	78
TAS	74	21	16	111
NT	224	1	0	225
ACT	59	34	1	94
Australia	46	48	3	96

	Electricity	Gas	LPG & firewood	Total
Class 2				
NSW	37	11	0	48
VIC	20	33	0	53
QLD [b]	70	1	0	71
SA	90	34	0	124
WA	60	29	0	89
TAS	194	21	0	215
NT	214	1	0	215
ACT	109	28	0	137
Australia	47	18	0	66

[a] Results reflect the use of a heat pump water heater as the energy performance benchmark for Class 2 dwellings in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions (see Box 6.1).

[b] Results reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions).

Note: As these estimates are at a household level, they are based on retail energy prices. A negative value represents an increase in energy bills. Excludes energy bill savings associated with thermal bridging mitigation measures for steel framed buildings. Totals may not add up due to rounding.

Source: ACIL Allen.

Table 8.3 provides the annual average energy bill savings over a 30 year period for the combined option of using Option A for Class 1 dwellings and Option B for Class 2 dwellings. The annual average energy bill savings are higher for Class 2 dwellings than for Class 1 dwellings.

Table 8.3 Estimated average annual energy bill savings over 30 years (over asset lifecycle) of applying Option A for Class 1 dwellings and Option B for Class 2 dwellings, undiscounted ($2021)

	Class 1	Class 2
NSW	255	33
VIC	295	37
QLD	43	34
SA	164	71
WA	105	52
TAS	178	111
NT	449	100
ACT	143	75
Australia	183	40

[a] Energy bill savings include energy savings from all fuels.

Notes: Results reflect the resetting of the energy performance benchmark for Class 2 dwellings in Queensland to be a gas instantaneous water heater (the same as for all other jurisdictions, see Box 6.1). Totals may not add up due to rounding.

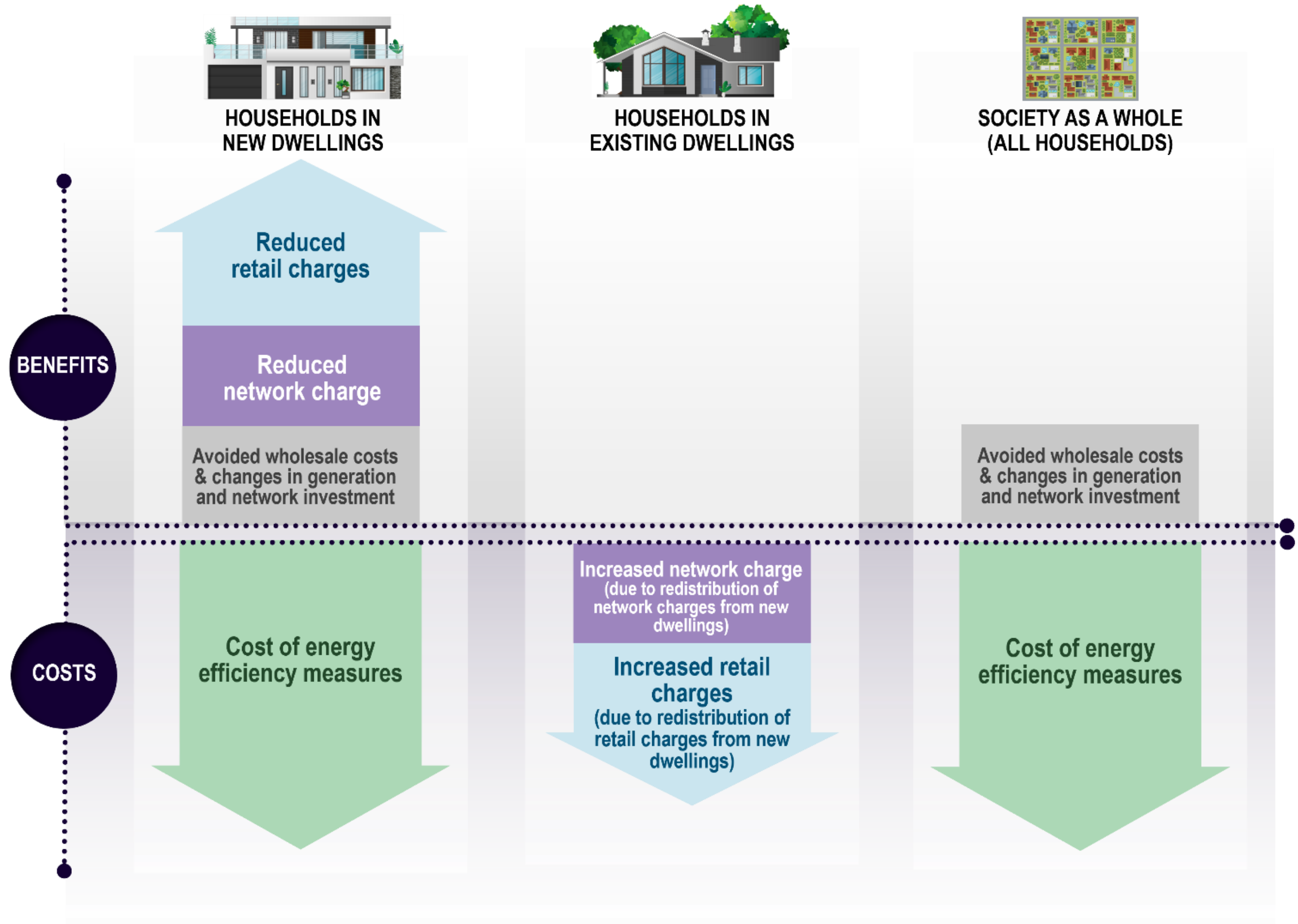
Source: ACIL Allen.

8.1.1 Understanding distributional impacts

It may appear odd that the impacts of the proposed changes to the NCC are more favourable at a household level than at the societal level.

This is because the value of energy savings for households is greater than the resource savings to society overall. Fixed network and retail costs still need to be recovered by energy retailers. Thereby, a large part of the household's benefit is a result of a transfer between individuals — from society as a whole to other energy users. This is illustrated in Figure 8.1.

Figure 8.1 Redistribution of costs and benefits



Note: The scale of impacts is illustrative only. The diagram excludes the change in wholesale electricity prices, which is an equal benefit and cost to Others.
Source: ACIL Allen.

The energy charges that are reduced for households, but which do not result in costs being avoided, are transferred to other energy users — even those who have nothing to do with the proposed changes to the NCC — through higher energy prices. The benefit to households that are subject to the proposed changes to the NCC is exactly offset by increased costs elsewhere. This type of transfer is called a pecuniary externality. In modelling the net impacts, this transfer at an economy-wide level is accounted for by using wholesale energy prices and changes in generation and network investment (as a proxy for avoided resource costs), which is why it is used in this cost benefit analysis (CBA).

While it is true that households can be made better off, this is because a large part of this benefit is transferred to the rest of society. The impact analysis has to consider all net impacts, including these transfers, at the society level. As a result, some of the benefit to households must be offset when assessing the policy overall at the society level.

This approach is consistent with the Australian Government's handbook on cost-benefit analysis, which states:

> One of the first tasks for the analyst is to distinguish the allocative effects of a project, that is, the effects due to changes in the use of resources and in outputs, from the distributional effects. Generally speaking it is only changes in resource use that involve opportunity costs. Distributional effects may be regarded as 'transfers' – that is, some individuals are made better off while others are made worse off. Distributional effects do not add or subtract from estimated net social benefit. However, they may affect social welfare if the judgement is made that one group derives more value from the resources than another group.[245]

The distributional effects referred to in the handbook on cost-benefit analysis would be included in the economy-wide cost benefit analysis if retail electricity prices had been used to value energy savings.

Similarly, the Houston Kemp report for the Australian Government Residential Buildings Regulatory Impact Statement Methodology states that:

> Previous studies have used reduction in the retail bill as the benefit, which represents the financial savings to households based on existing tariffs. However, we believe a more accurate approach is to estimate the resource cost savings from reduced electricity and gas consumption, i.e., reduction in network and wholesale costs.[246]

And that:

> To estimate the benefit from reductions in electricity generation costs, average wholesale market prices can be used as they typically represent suitable estimates for the resource cost savings.[247]

8.2 Housing affordability

As illustrated in Figure 8.2, housing affordability is determined by a range of factors influencing demand and supply. Housing supply is driven by factors such as land availability, construction costs, profitability for developers and infrastructure costs such as water, power, sewerage and public transport. Housing demand is driven by factors such as the number and type of households looking for housing, household income and preferences (such as size, location and tenure type), investor demand and interest rates.

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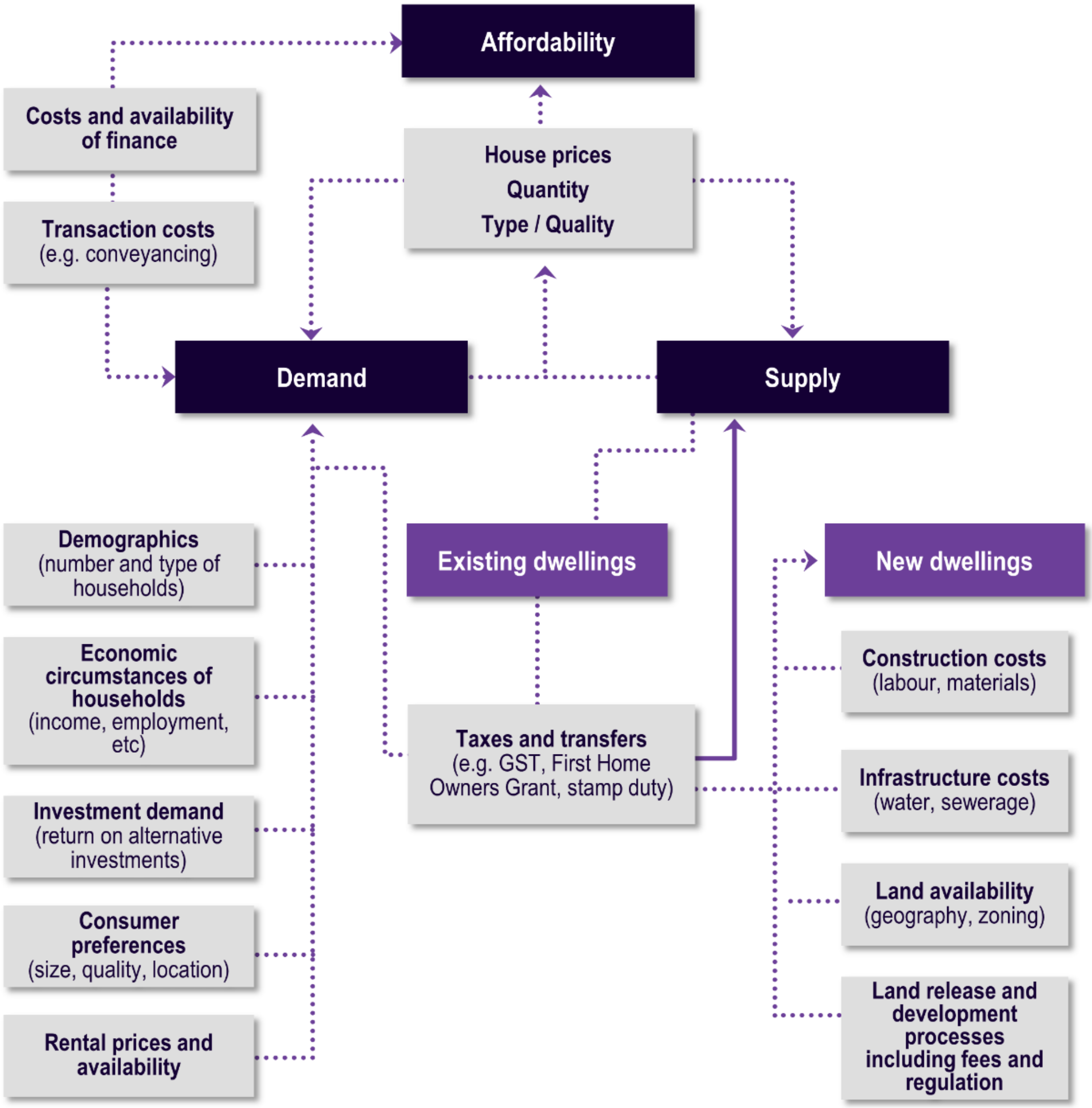
[245] Australian Government, *Handbook of Cost-Benefit Analysis*, January 2006, page 27.

[246] Houston Kemp, *Residential Buildings Regulatory Impact Statement Methodology,* 66 April 2017, page 14.

[247] Ibid, page 15.

Figure 8.2 Factors affecting housing affordability



Source: Adapted from National Housing Supply Council (NHSC) 2010, 2nd State of Supply Report, Canberra, April 2010.

In the context of this report, housing affordability is likely to be affected by the proposed NCC changes in two main ways:

— it may change households' disposable income through the reduction of household costs due to improvements in energy efficiency, which reduces energy bills (and the economic resources required to produce these services)

— sellers of houses who make additional investments in energy efficiency measures to comply with the proposed NCC changes may seek to raise their price to compensate for the cost of that investment.

When you look at these factors, some house prices may go up, and some may go down. The outcome for every dwelling is not clear, but the average outcome is likely to reflect overall changes in real resource use (which relates to the cost of complying with the new requirements and the benefits of avoided energy use).

There are many parties in the property market that would be affected by the proposed changes to the NCC. Sometimes the seller would be the one paying the costs, and sometimes it is the buyer of the property that would enjoy the benefits of the investment, so there is a question about which party bears the costs or enjoys the benefits.

This situation is similar to analysis of the incidence of taxes and charges. Sometimes the legal incidence of the tax is on the supplier and sometimes it is found that, through market mechanisms, the cost of this tax is passed through to consumers. So, the legal incidence of a tax can be different to the economic incidence. This often depends on the nature of competition in the market, with more competitive markets resulting in greater pass through.

The property market is already a very competitive market with tight margins. As such, it is likely that the costs and benefits of the NCC 2022 stringency settings would be passed through to the final buyer of a property (i.e. to households). This provides a conservative basis for estimating the effect on housing affordability. It is possible that some buyers would do better, and it is also possible that some sellers would do better. This section of the report analyses the average effect for the community at large.

8.2.1 Impacts on typical households

While housing affordability is examined in the next section using a selection of widely accepted indicators to measure housing affordability, it is useful to have a discussion about what the proposed NCC changes could mean from the perspective of typical households.

The proposed changes to the NCC would require an up-front investment, while the benefits of lower energy use would accrue over time. As mentioned above, the costs of complying with the NCC are likely to be passed through to property buyers in the form of slightly higher house prices.

Table 8.4 shows the effects that costs of complying with the new NCC energy efficiency requirements would have on median house prices in different states and territories.[248] As shown in this table, overall, it is estimated that the proposed changes would result in small increases in prices for all houses and units across Australia under both policy options. On average, it is estimated that the price of dwellings across Australia would increase:

— under Option A, between 0.1 per cent (in Queensland and ACT) and 1.3 per cent (in the Northern Territory) for houses, and between 0.5 per cent (in Tasmania) and 1.3 per cent (in the Northern Territory) for apartments

[248] Median house prices reflect prices for all dwellings (both new and existing) but are used in the analysis to illustrate the potential impact of the new proposed requirements on housing affordability.

— under Option B, between 0.1 per cent (in NSW, ACT, Western Australia and Queensland) and 0.4 per cent (in Tasmania) for houses, and between 0.1 per cent (in NSW, Victoria and Western Australia) and 0.2 per cent (in Queensland) for apartments.

Table 8.4 Estimated impact of the proposed NCC requirements on median house prices across states and territories

State/Territory	Option A			Option B		
	Current dwelling price	Dwelling price under NCC 2022	% Change	Current dwelling price	Dwelling price under NCC 2022	% Change
HOUSES						
NSW	$860,000	$863,319	0.4%	$860,000	$861,119	0.1%
VIC	$750,000	$753,310	0.4%	$750,000	$751,870	0.2%
QLD	$568,000	$568,710	0.1%	$568,000	$568,356	0.1%
SA	$483,000	$484,808	0.4%	$483,000	$483,846	0.2%
WA	$490,000	$491,020	0.2%	$490,000	$490,609	0.1%
TAS	$500,000	$503,135	0.6%	$500,000	$501,833	0.4%
NT	$538,000	$544,762	1.3%	$538,000	$540,605	0.5%
ACT	$890,000	$891,243	0.1%	$890,000	$890,600	0.1%
UNITS						
NSW	$720,000	$724,279	0.6%	$720,000	$720,534	0.1%
VIC	$609,000	$613,656	0.8%	$609,000	$609,542	0.1%
QLD[a]	$435,000	$440,004	1.2%	$435,000	$435,764	0.2%
SA	$367,000	$370,410	0.9%	$367,000	$367,585	0.2%
WA	$390,000	$392,869	0.7%	$390,000	$390,251	0.1%
TAS	$420,000	$422,106	0.5%	$420,000	$421,005	0.2%
NT	$365,000	$369,828	1.3%	$365,000	$366,271	0.3%
ACT	$525,000	$527,889	0.6%	$525,000	$525,844	0.2%

[a] Results for units under Option A reflect the use of a heat pump water heater as the energy performance benchmark in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions. Results for units under Option B reflect the resetting of the energy performance to be a gas instantaneous water heater (see Box 6.1).

Note: Median house prices as at December quarter 2021 sourced from CoreLogic Property Value. Prices reflect prices for all dwellings (both new and existing), but are used in the analysis to illustrate the potential impact of the new proposed requirements on housing affordability.

Source: ACIL Allen based on CoreLogic.

There are many ways to put these impacts into context. One way of putting these house price increases into context is to compare them to increases in the cost of building a house from one year to another. For instance, over the period March 2021 to March 2022, input prices to house construction rose 15.4 per cent.[249,250] This is significantly higher than the highest expected increase in house prices due to compliance with the proposed NCC requirements in NSW (for both houses and units under Option A).

Another way to put these increases into context is to consider how much extra a household would have to pay in mortgage repayments because of these price increases. Table 8.5 presents these impacts. Notably, as the cost of complying with the new NCC 2022 requirements would be included in the house price, homebuyers would not have to pay it upfront, rather, this extra cost would become part of their annual mortgage payments. As indicated in Table 8.5, it is estimated that the increases in repayments range:

- under Option A:
  - from $31 per annum (or around 59 cents per week) for a house in Queensland, to $293 per annum (or around $5.64 per week) for a house in the Northern Territory
  - from $91 per annum (or around $1.76 per week) for an apartment in Tasmania, to $217 per annum (or around $4.17 per week) for an apartment in Queensland
- under Option B:
  - from $49 per annum (or around 30 cents per week) for a house in NSW, to $113 per annum (or around $2.17 per week) for a house in the Northern Territory
  - from $11 per annum (or around 21 cents per week) for an apartment in Western Australia, to $55 per annum (or around $1.06 per week) for an apartment in the Northern Territory.

However, repayment increases would be offset by lower energy bills as a result of the energy efficiency improvements in the house. These lower bills would have the effect of increasing household disposable income as lower bills imply the availability of extra funds for spending on other items such as mortgage repayments. These savings for the first year of the regulations are also presented in Table 8.5. As shown in this table:

- Under Option A, all households in houses across all states and territories are estimated to experience a net benefit in the first year of the new regulations as the savings arising from lower energy bills are more than enough to offset the increase in annual mortgage repayments. Furthermore, most households in apartments across all states and territories (except for households in apartments in Victoria) would also experience net benefits in the first year. Households in apartments in Victoria would experience $45 in net costs in the first year.

[249] ABS notes that the main contributors to this increase were: timber, board and joinery (+4.0% - driven by plywood and board); other metal products (+4.0% - driven by aluminium windows and doors); and other materials (+4.6% - driven by carpet and floor covering). For more details see: https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/producer-price-indexes-australia/latest-release#data-download

[250] ABS 2021, *Producer Price Indexes, Australia, Cat. No. 6427.0, Table 17. Output of the Construction industries, subdivision and class index numbers*, March.

— Under Option B, most households in both houses and apartments across all states and territories (except households in houses in Queensland) are estimated to experience a net benefit in the first year of the new regulations as the savings arising from lower energy bills are more than enough to offset the increase in annual mortgage repayments. Households in houses in Queensland would experience a small increase in net costs in the first year (of around $5).

Notably, over time, as utility prices changes, these impacts would change.[251]

[251] The best way to measure the effects that these expected benefits would have over time on homeowners is to look at the percentage of income that they would have to dedicate to mortgage repayments over the life of their house. This information is presented in Table 8.7.

Table 8.5 Estimated impact of capital outlays to comply with proposed NCC requirements on mortgage repayments

State/ territory	Option A					Option B				
	Annual mortgage payments			Offset (savings) from lower utility bills in 2022 ($)	Net impact ($)[a]	Annual mortgage payments			Offset (savings) from lower utility bills in 2022 ($)	Net impact ($)[a]
	Currently ($)	Under NCC 2022 ($)	Change ($)			Currently ($)	Under NCC 2022 ($)	Change ($)		
HOUSES										
NSW	$37,288	$37,432	$144	$326	$183	$37,288	$37,336	$49	$86	$37
VIC	$32,518	$32,662	$144	$324	$180	$32,518	$32,599	$81	$185	$104
QLD	$24,627	$24,658	$31	$83	$53	$24,627	$24,643	$15	$10	-$5
SA	$20,942	$21,020	$78	$206	$128	$20,942	$20,979	$37	$80	$44
WA	$21,245	$21,290	$44	$144	$99	$21,245	$21,272	$26	$78	$52
TAS	$21,679	$21,815	$136	$276	$140	$21,679	$21,758	$79	$111	$31
NT	$23,327	$23,620	$293	$594	$301	$23,327	$23,439	$113	$225	$112
ACT	$38,588	$38,642	$54	$212	$158	$38,588	$38,615	$26	$94	$68
UNITS										
NSW	$31,218	$31,403	$186	$193	$7	$31,218	$31,241	$23	$48	$25
VIC	$26,405	$26,607	$202	$157	-$45	$26,405	$26,428	$24	$53	$29
QLD [b]	$18,861	$19,078	$217	$284	$67	$18,861	$18,894	$33	$71	$38
SA	$15,912	$16,060	$148	$277	$129	$15,912	$15,938	$25	$124	$99
WA	$16,910	$17,034	$124	$177	$53	$16,910	$16,920	$11	$89	$78
TAS	$18,210	$18,302	$91	$344	$253	$18,210	$18,254	$44	$215	$171

State/ territory	Option A					Option B				
	Annual mortgage payments			Offset (savings) from lower utility bills in 2022 ($)	Net impact ($)[a]	Annual mortgage payments			Offset (savings) from lower utility bills in 2022 ($)	Net impact ($)[a]
	Currently ($)	Under NCC 2022 ($)	Change ($)			Currently ($)	Under NCC 2022 ($)	Change ($)		
NT	$15,826	$16,035	$209	$352	$142	$15,826	$15,881	$55	$215	$160
ACT	$22,763	$22,888	$125	$292	$167	$22,763	$22,799	$37	$137	$100

[a] Impacts are for the first year of the proposed NCC changes. Negative net impacts represent an overall cost to households (i.e. a situation where the increase in mortgage repayments is higher than the increase in the household's annual disposable income).

[b] Results for units under Option A reflect the use of a heat pump water heater as the energy performance benchmark in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions. Results for units under Option B reflect the resetting of the energy performance to be a gas instantaneous water heater (see Box 6.1).

Note: Based on median house price data from the December Quarter 2021 sourced from CoreLogic Property Value and the following mortgage assumptions: prime borrower, standard loan, 20 per cent deposit (i.e. Loan to Value ratio (LVR)=80 per cent), standard variable lending rate of all institutions for new loans to owner occupiers of 2.56 per cent p.a. (as at 31 December 2021, sourced from the Reserve Bank of Australia (RBA)) and a 25 year repayment period. Includes the impacts on house prices outlined in Table 8.4. Totals may not add up due to rounding.

Source: ACIL Allen.

8.2.2 Housing affordability indicators

This section details the impacts of the proposed changes to the NCC on a number of housing affordability indicators.

Measurement basis

There are a range of approaches that can be used to measure and assess housing affordability. We have used two widely known affordability indicators to evaluate the potential impacts of the proposed changes to the NCC on housing affordability. These are outlined below.

— **The ratio of mortgage repayment to household income** — this measure indicates the proportion of gross income used for mortgage repayments. Financial institutions have traditionally applied a rule of thumb of not allowing households to take out home loans requiring more than 30 per cent of gross income to service. An increase in this measure represents decreased housing affordability.

— **The median multiple** — the median multiple (or house price to income ratio) reflects the 'years of gross income' required to purchase a house within individual housing markets. A generally accepted definition of affordability is that house prices should not cost more than three times the median household gross income to be affordable. An increase in this measure represents decreased housing affordability.

Methodology used in affordability analysis

In broad terms, the analysis of the affordability indicators presented in this section was undertaken as follows.

1. First, we estimated the impact of the proposed NCC requirements on house prices using the estimated costs of complying with the new requirements. These impacts are outlined in Table 8.4.
2. Second, we estimated the impact of the proposed NCC requirements on household disposable income. These impacts are outlined in Table 8.6. In reality, overall household incomes are not expected to change with the new NCC requirements. However, future occupants of properties that have had an energy efficiency improvement as a result of the new requirements would experience relatively lower energy bills. This would have the effect of increasing household disposable income as lower bills imply the availability of extra funds for spending on other items such as mortgage repayments. Therefore, for the purposes of this analysis, such increases in disposable income are reflected as increases in gross median household income so that the benefits of the new NCC requirements can be reflected in the housing affordability indicators.

   Table 8.6 includes estimates of changes in disposable income using two approaches:

   – One where current income is adjusted by including the present value of the lifetime benefits of the proposed NCC changes in the calculation. While this approach accounts in full for variations in future energy prices, it assumes that all future benefits are received today, which means that income for subsequent years would be the same as in the BAU. The results under this approach are shown in the 4th and 9th columns in the table. While informative, this approach is unrealistic as households would only receive the benefits from the implemented changes on a year on year basis.

- A second approach where current disposable income is adjusted by including in the calculation only the value of the benefits of the proposed NCC changes in the first year of the regulations (2022).[252] The results of this approach are shown in the 6th and 11th columns in the table. While this approach is more realistic, it does not account for changes in the value of benefits on a year on year basis as energy prices change.

Focusing on the second approach described above, Table 8.6 shows that the new NCC requirements would result in negligible increases in gross median household income (or, in reality, disposable income) for all the analysed households under both options.

3. Third, we calculated two sets of affordability indicators:
   - a set of affordability indicators for each state and territory based on current median house prices and disposable income
   - a set of affordability indicators for each state and territory based on the median house prices and disposable income under the proposed changes to NCC requirements. These indicators are estimated on the assumption that the costs and benefits associated with the proposed changes are fully passed through to property buyers with the costs of the proposed change reflected as increased house prices and the benefits reflected as increased disposable incomes.

[252] The economic analysis in this RIS has been undertaken assuming that the proposed changes to the NCC start in 2022. However, in practice, it is anticipated that the regulations would start on the second half of the year and will likely have a transition period.

Table 8.6 Estimated impacts of proposed NCC changes on gross median household disposable income

State/ territory	Option A					Option B				
	Current NCC [a]	Under new NCC (lifetime benefits) [b]	% Change	Under new NCC (1st year benefits) [c]	% Change	Current NCC [a]	Under new NCC (lifetime benefits) [b]	% Change	Under new NCC (1st year benefits) [c]	% Change
HOUSES										
NSW	$87,284	$91,115	4.4%	$87,610	0.4%	$87,284	$88,332	1.2%	$87,370	0.1%
VIC	$85,571	$89,834	5.0%	$85,895	0.4%	$85,571	$87,956	2.8%	$85,755	0.2%
QLD	$83,456	$84,246	0.9%	$83,539	0.1%	$83,456	$83,601	0.2%	$83,466	0.01%
SA	$71,586	$74,058	3.5%	$71,793	0.3%	$71,586	$72,616	1.4%	$71,667	0.1%
WA	$89,970	$91,630	1.8%	$90,114	0.2%	$89,970	$90,892	1.0%	$90,049	0.1%
TAS	$66,836	$69,820	4.5%	$67,112	0.4%	$66,836	$68,155	2.0%	$66,947	0.2%
NT	$102,735	$109,610	6.7%	$103,329	0.6%	$102,735	$105,370	2.6%	$102,960	0.2%
ACT	$120,959	$123,221	1.9%	$121,171	0.2%	$120,959	$122,024	0.9%	$121,053	0.1%
UNITS										
NSW	$87,284	$89,188	2.2%	$87,476	0.2%	$87,284	$87,802	0.6%	$87,332	0.1%
VIC	$85,571	$87,263	2.0%	$85,727	0.2%	$85,571	$86,157	0.7%	$85,624	0.1%
QLD [d]	$83,456	$86,146	3.2%	$83,740	0.3%	$83,456	$84,111	0.8%	$83,527	0.1%
SA	$71,586	$74,273	3.8%	$71,863	0.4%	$71,586	$72,817	1.7%	$71,710	0.2%
WA	$89,970	$91,700	1.9%	$90,148	0.2%	$89,970	$90,884	1.0%	$90,060	0.1%

State/ territory	Option A					Option B				
	Current NCC [a]	Under new NCC (lifetime benefits) [b]	% Change	Under new NCC (1st year benefits) [c]	% Change	Current NCC [a]	Under new NCC (lifetime benefits) [b]	% Change	Under new NCC (1st year benefits) [c]	% Change
TAS	$66,836	$70,068	4.8%	$67,180	0.5%	$66,836	$68,896	3.1%	$67,051	0.3%
NT	$102,735	$106,572	3.7%	$103,086	0.3%	$102,735	$104,671	1.9%	$102,950	0.2%
ACT	$120,959	$123,756	2.3%	$121,252	0.2%	$120,959	$122,267	1.1%	$121,096	0.1%

[a] Median household income (that is, the midpoint when all people are ranked in ascending order of income) for each state and territory in 2021 calculated using ABS data.

[b] Disposable income includes the present value of the lifetime benefits of the changes, calculated using a 7 per cent discount rate.

[c] Disposable income includes only the value of the benefits in the first year of the regulations (2022). These benefits vary on a year on year basis as energy prices change.

[d] Results for units under Option A reflect the use of a heat pump water heater as the energy performance benchmark in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions. Results for units under Option B reflect the resetting of the energy performance to be a gas instantaneous water heater (see Box 6.1).

Source: ACIL Allen

Affordability impacts

Table 8.7 and Table 8.8 show the effects of the proposed changes in the NCC on the two affordability indicators estimated for this report (estimated using the discounted lifetime benefits and the benefits only in the first year of the regulations).

The proportion of income used to pay a mortgage outlined in Table 8.7 would remain practically the same for all households analysed across both options (differences are only noticeable at the second decimal level for most jurisdictions). Notably:

— Past analyses have included the present value of the lifetime benefits of the changes in the calculation of this ratio. While this approach accounts in full for variations in future energy prices, it assumes that all future benefits are received today, which means that ratios for subsequent years would be higher as all the benefits would have been counted in the first year. The results under this approach are shown in the 3rd and 6th columns in the table.

— Using only the value of the benefits in the first year of the regulations (2022) the proportion of income required for mortgage repayments (shown in the 4th and 7th columns in the table) would increase for some dwellings. However, these increases are immaterial. This approach does not account for changes in the value of benefits on a year on year basis as energy prices change.

— This indicator remains broadly unchanged mainly due to the fact that the additional costs of the proposed changes are included in the initial mortgage and hence amortised over time.

The 'years of gross income' required to purchase a house (calculated using the value of benefits in 2022) outlined in Table 8.8 are estimated to increase slightly for:

— households in houses in South Australia and the Northern Territory and households in apartments in NSW, Victoria, Queensland, South Australia, Western Australia and ACT under Option A

— households in houses in South Australia and the Northern Territory and households in apartments in NSW under Option B.

These increases represents a decrease in housing affordability in these markets.

Overall, the two housing affordability indicators analysed suggest that the proposed changes to the NCC would have no major effects on housing affordability.

Table 8.7 Estimated impacts of the proposed NCC changes on the proportion of income used for mortgage repayments

State/ territory	Option A			Option B		
	Currently	Under new NCC (lifetime benefits)[a]	Under new NCC (1st year benefits) [b]	Currently	Under new NCC (lifetime benefits)[a]	Under new NCC (1st year benefits) [b]
HOUSES						
NSW	43%	41%	43%	43%	42%	43%
VIC	38%	36%	38%	38%	37%	38%
QLD	30%	29%	30%	30%	29%	30%
SA	29%	28%	29%	29%	29%	29%
WA	24%	23%	24%	24%	23%	24%
TAS	32%	31%	33%	32%	32%	33%
NT	23%	22%	23%	23%	22%	23%
ACT	32%	31%	32%	32%	32%	32%
UNITS						
NSW	36%	35%	36%	36%	36%	36%
VIC	31%	30%	31%	31%	31%	31%
QLD [c]	23%	22%	23%	23%	22%	23%
SA	22%	22%	22%	22%	22%	22%
WA	19%	19%	19%	19%	19%	19%
TAS	27%	26%	27%	27%	26%	27%
NT	15%	15%	16%	15%	15%	15%
ACT	19%	18%	19%	19%	19%	19%

[a] Disposable income includes the present value of the lifetime benefits of the changes.

[b] Disposable income includes only the value of the benefits in the first year of the regulations (2022). These benefits vary on a year on year basis as energy prices change.

[c] Results for units under Option A reflect the use of a heat pump water heater as the energy performance benchmark in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions. Results for units under Option B reflect the resetting of the energy performance to be a gas instantaneous water heater (see Box 6.1).

Note: Cells highlighted in red denote a decrease in affordability. Based on median house price data from the December Quarter 2021 sourced from CoreLogic, the median household income (that is, the midpoint when all people are ranked in ascending order of income) for each state and territory calculated using ABS data, and the following mortgage assumptions: prime borrower, standard loan, 20 per cent deposit (i.e. LVR=80 per cent), standard variable lending rate of all institutions for new loans to owner occupiers of 2.56 per cent p.a. (as at 31 December 2021, sourced from RBA) and a 25 year repayment period.

Source: ACIL Allen.

Table 8.8 Estimated impacts of the proposed NCC changes on the median multiple

State/ territory	Option A			Option B		
	Currently	Under new NCC (lifetime benefits)[a]	Under new NCC (1st year benefits)[b]	Currently	Under new NCC (lifetime benefits)[a]	Under new NCC (1st year benefits)[b]
HOUSES						
NSW	9.9	9.5	9.9	9.9	9.7	9.9
VIC	8.8	8.4	8.8	8.8	8.5	8.8
QLD	6.8	6.8	6.8	6.8	6.8	6.8
SA	6.7	6.5	6.8	6.7	6.7	6.8
WA	5.4	5.4	5.4	5.4	5.4	5.4
TAS	7.5	7.2	7.5	7.5	7.4	7.5
NT	5.2	5.0	5.3	5.2	5.1	5.3
ACT	7.4	7.2	7.4	7.4	7.3	7.4
UNITS						
NSW	8.2	8.1	8.3	8.2	8.2	8.3
VIC	7.1	7.0	7.2	7.1	7.1	7.1
QLD[c]	5.2	5.1	5.3	5.2	5.2	5.2
SA	5.1	5.0	5.2	5.1	5.0	5.1
WA	4.3	4.3	4.4	4.3	4.3	4.3
TAS	6.3	6.0	6.3	6.3	6.1	6.3
NT	3.6	3.5	3.6	3.6	3.5	3.6
ACT	4.3	4.3	4.4	4.3	4.3	4.3

[a] Disposable income includes the present value of the lifetime benefits of the changes.

[b] Disposable income includes only the value of the benefits in the first year of the regulations (2022). These benefits vary on a year on year basis as energy prices change.

[c] Results for units under Option A reflect the use of a heat pump water heater as the energy performance benchmark in Queensland and a gas instantaneous water heater benchmark for all other jurisdictions. Results for units under Option B reflect the resetting of the energy performance to be a gas instantaneous water heater (see Box 6.1).

Note: Cells highlighted in red denote a decrease in affordability. Based on median house price data from the December Quarter 2021 sourced from CoreLogic, the median household income (that is, the midpoint when all people are ranked in ascending order of income) for each state and territory calculated using ABS data. The impact of the proposed NCC changes on disposable income re outlined in and the impacts on house prices are outlined in Table 8.4.

Source: ACIL Allen.

9 Other impacts

This chapter discusses other potential impacts of the proposed energy efficiency requirements in the NCC 2022 that were not quantified in the CBA. The discussion is based on existing research and literature and on a small number of consultations held with selected stakeholders for the RIS.

9.1 Non-quantified benefits

In addition to the impacts quantified in the CBA of the proposed new energy efficiency requirements in the NCC, there are a number of other impacts (both costs and benefits) associated with energy efficiency – both private and public that cannot be quantified due to a lack of existing data for the Australian context. These multiple impacts were mapped in our report *Assessment Framework for the Multiple Impacts of Household Energy Efficiency* (2017) (see Figure 9.1) and include the impacts of energy efficiency on:

— health[253] and wellbeing

— the energy system

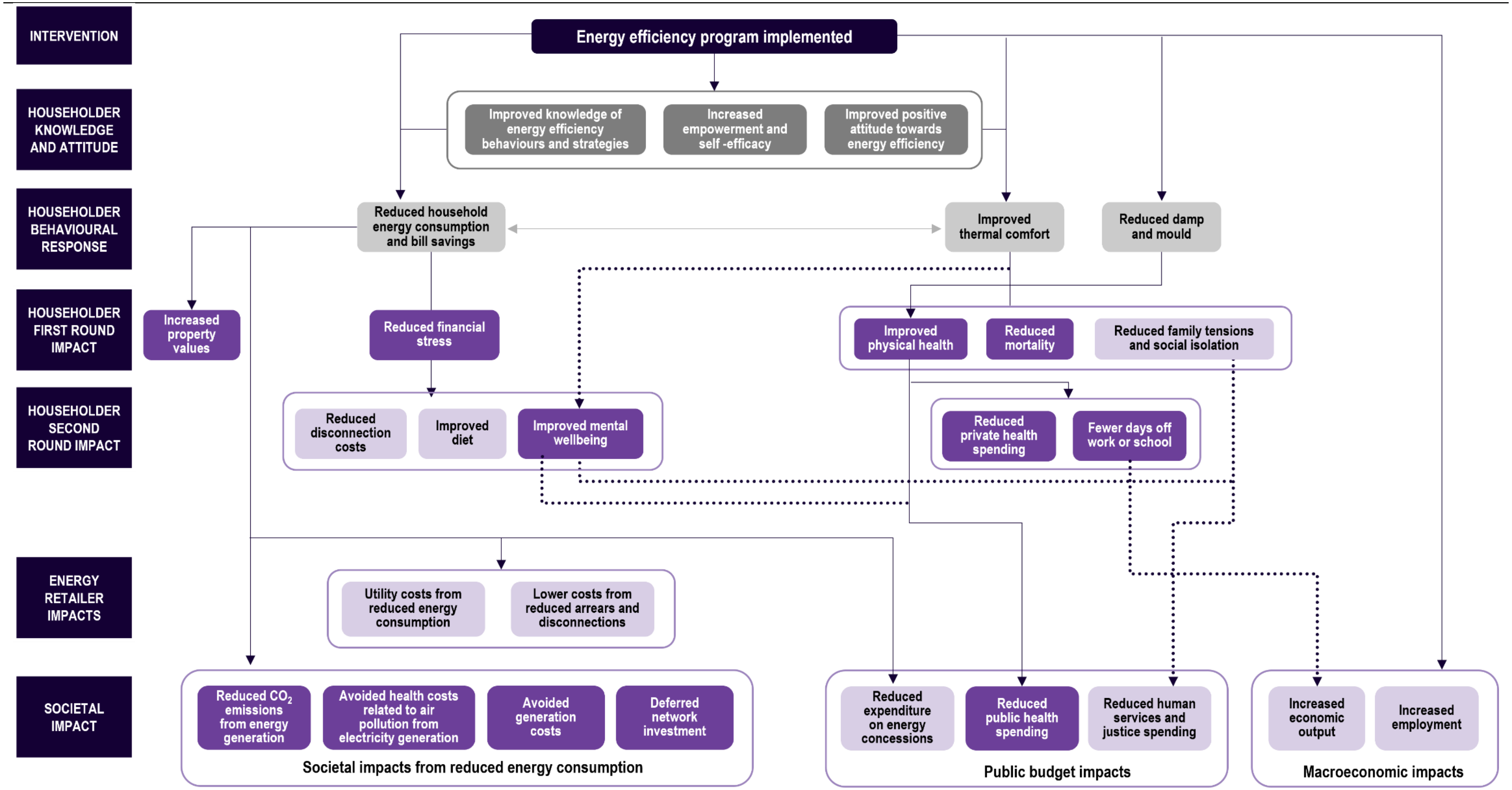
— the overall economy

— other participant benefits.

These benefits are briefly discussed in the sections below.

[253] As noted in section 5.5.8, health benefits are partially quantified/modelled.

Figure 9.1 Energy efficiency impacts logic map



Note: impacts presented in a darker shade are, to date, underpinned by a more substantial evidence base than those in a lighter shade.
Source: ACIL Allen.

9.1.1 Health and wellbeing

One of the objectives of the NCC is to improve occupant health and amenity. Residential energy efficiency actions can result in a number of health-related impacts in addition to the direct observable energy savings. Health and wellbeing impacts can materialise through three main pathways:

1. Improved thermal quality – which reduces mortality from hot and cold extremes, as well as symptoms of a range of diseases such as respiratory and cardiovascular diseases, allergies, arthritis and rheumatism. Alleviation of chronic thermal discomfort can also contribute to improved mental wellbeing. Other indirect impacts (or co-benefits) of thermal quality that have been suggested in the literature, but are not yet well-established[254] include:
   - lessened family tensions if installation of energy efficiency measures allows more areas of the dwelling to be heated, lessening the need for the family to crowd into a single heated room
   - reduced social isolation if energy efficiency measures reduce occupants' embarrassment with their uncomfortable conditions
   - improved social cohesion and sense of community among residents
   - higher rates of school attendance
   - healthier lifestyles
   - improved access to local services.
2. Improved air indoor quality and reduced dampness – which can lead to improved physical health, and reduced mortality and morbidity.
3. Reduced household energy consumption and bill savings – reduced spending on energy as a result of an energy efficiency intervention can lead to reduced financial stress among households experiencing energy bill pressure. This in turn can have other positive indirect effects, including:
   - reduced disconnection costs
   - improved mental wellbeing – energy efficiency may lead to improved mental health and wellbeing outcomes through reducing financial stress related to high energy bills and fear of falling in debt
   - reduced malnutrition and obesity if funds freed up from lower energy bills are used to purchase better quality food.

[254] IEA 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency.

New dwellings built under the BAU (i.e. under the current energy efficiency standards in NCC 2019) already provide a good level of thermal comfort and indoor air quality. The health effects of proposed changes in the NCC through pathways 1) and 2) above are therefore less material than upgrading existing dwellings (built under earlier versions of the NCC). For example, a study that examined the possible correlation of building energy ratings with heat-related health hazard during heatwave based on case data from Melbourne's 2009 heatwave conditions found that:[255]

> [the] mortality rate from a Melbourne 2009 type [event], as well as, future more intense heatwave[s] may reduce by 90% if [the] entire [stock of] existing lower energy star rated houses can be upgraded to minimum 5.4 star energy rating

This indicates that the reduction in mortality related to extreme weather events is more substantial when comparing the proposed energy efficiency provisions in the NCC 2022 with older building stock than an increase from a 6 to 7 star rating as proposed for the NCC 2022.

The proposed increase from 6 to 7 stars will deliver a level of thermal comfort with less reliance on heating and cooling. Indeed, as noted by NatHERS[256], higher star ratings result in passive improvements to comfort:

- 0 star rating means the building shell does practically nothing to reduce the discomfort of hot or cold weather
- a 6 star rating indicates good, but not outstanding, thermal performance
- a 10 star rated home may not need any artificial cooling or heating to keep the occupants of a dwelling comfortable.

As discussed before, the proposed changes to the NCC would result in net benefits for some households, and net costs for others. Those households experiencing a net reduction in energy bills could experience some of the benefits outlined in pathway 3) above, while those experiencing a net increase in bills could experience the opposite effects.

9.1.2 Resilience to extreme weather and blackouts

One of the objectives of the NCC is to improve the resilience of a building to extreme weather and blackouts. The impact of the NCC on the resilience of a building to extreme weather and blackouts can be considered in terms of the impact on the likelihood of extreme weather and blackouts and the consequence of extreme weather and blackouts.

The proposed provisions for the NCC 2022 will have an immaterial impact on the likelihood of extreme weather because the reduction in GHG emissions is not material relative to global GHG emissions.

Blackouts may be caused by extreme weather or where demand exceeds supply. As the proposed provisions for the NCC 2022 will have an immaterial impact on the likelihood of extreme weather, they will have an immaterial impact on the likelihood of blackouts caused by extreme weather. The proposed provisions for the NCC 2022 result in marginal decreases in the peak demand for electricity relative to the total peak demand for electricity. Accordingly, the proposed provisions for the NCC

[255] Alam, M, Sanjayan J, Zou P X W, Stewart M and J. Wilson 2016, *Modelling the correlation between building energy ratings and heat-related mortality and morbidity*, Sustainable Cities and Society, 22: 29-39.

[256] Department of the Environment and Energy (DoEE) 2019, *NatHERS assessor handbook*, Canberra.

2022 impacts will have an impact on the likelihood of blackouts due to demand exceeding supply, albeit not material.

As discussed above, the proposed increase from 6 to 7 stars will deliver a level of thermal comfort with less reliance on heating and cooling. The reduced reliance on heating and cooling for thermal comfort will mitigate the consequences of extreme weather, although the benefits are not able to be quantified.

The impact of proposed changes in the NCC on the consequences of blackouts are not material as there is not a requirement to install battery storage, and the installation of solar PV systems is not proposed to be mandatory.

9.1.3 Energy system

As noted in our 2017 report[257], energy efficiency interventions can lead to tangible benefits along the entire energy supply chain, if this consideration is taken into account during the design stage. The benefits for energy providers include[258,259]:

— improved system reliability

— enhanced capacity adequacy

— better ability to manage peak demand (as discussed in section 9.1.2)

— opportunities to defer generation and network infrastructure investments (these have been quantified for this RIS and outlined in Sections 7.2.2 and 7.2.3)

— reduced price volatility in wholesale markets.

Additional benefits specific to low income or vulnerable households include improved ability to manage energy bills, which in turn can lead to reduced arrears, unpaid debts and collection costs for energy utilities. To the extent to which these costs are borne by the utilities, the savings can (in a competitive market) be assumed to ultimately accrue to non-participants in the form of lower utility bills. If hardship or payment assistance programs are funded from general tax revenue, cost savings can be regarded as societal benefits[260].

As discussed in Section 7.5.3, the wholesale energy market modelling projects that the wholesale electricity price will be between 8 per cent lower and 8 per cent higher under the proposed changes to the energy efficiency requirements in the NCC 2022. In aggregate, the changes in wholesale electricity prices are projected to result in an increase in electricity costs for consumers of $1.9 billion using a 7 per cent discount rate, which represents a 0.6 per cent increase in wholesale electricity

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[257] AAC 2017, *Multiple Impacts of Household Energy Efficiency: an Assessment Framework*, report to Energy Consumers Australia, October, https://www.acilallen.com.au/projects/energy/multiple-impacts-of-household-energy-efficiency-an-assessment-framework.

[258] Lazar, J., Coburn, K. 2013, *Recognizing the full value of energy efficiency, The Regulatory Assistance Project (RAP)*, https://www.raponline.org/knowledge-center/recognizing-the-full-value-of-energy-efficiency/.

[259] IEA 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency.

[260] Lazar, J., Coburn, K. 2013, *Recognizing the full value of energy efficiency, The Regulatory Assistance Project (RAP)*, https://www.raponline.org/knowledge-center/recognizing-the-full-value-of-energy-efficiency/.

costs.[261] This is a distributional effect rather than a net societal cost, as the additional costs for consumers are additional revenues for generators.

9.1.4 Overall economy

There are two potential impacts of energy efficiency interventions on the overall economy:

- Public budget impacts — energy efficiency interventions can reduce public spending through:
  - reduced expenditure on energy concessions (if households receiving energy concessions reduce their energy consumption)
  - reductions in public health spending due to the health impacts discussed above
  - reduced demand on human services and the justice system due to improved mental wellbeing and reduced family tensions.
- Macroeconomic impacts — the macroeconomic impacts of energy efficiency cover effects occurring at national, international and regional levels. Energy efficiency may result in changes in the overall economy through two main sources of impact:
  - investment effects which arise from increased expenditure on energy efficient goods and services, which leads to higher production in these sectors but lower production in other sectors of the economy
  - energy demand reduction effects that operate through reduction (cost savings) in relation to energy-related expenditure leading to increased disposable income and higher business profits.

These two effects combined can lead to changes in macroeconomic variables such as Gross Domestic Product (GDP), employment, energy prices and the trade balance[262].

Furthermore, the reduction in public spending may lead to a reduction in taxation or a redirection of funds to other government policies and programs, which may be used to stimulate the economy. The investment effects may lead to further investment by industry in innovation to support a low carbon economy, although it would be difficult to distinguish the effects from the proposed changes to the NCC from those that are occurring under BAU.

[261] Wholesale electricity costs represent between 25 and 40 per cent of the retail electricity bill. The increase in retail electricity costs is therefore between 0.2 and 0.3 per cent.

[262] IEA 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency.

9.1.5 Other participant benefits

As noted by ACIL Allen[263] a number of other impacts linked to energy efficiency have been hypothesised, but there is insufficient available evidence to accurately quantify. The only impact that may be relevant to the proposed energy requirements in NCC 2022 is the potential creation of additional new business opportunities through demand for additional energy efficiency and renewable energy.[264,265]

9.2 Effects on competition

A number of stakeholders consulted for this project commented on the impact on competition for building supplies. They were particularly concerned that the requirements would incentivise builders to minimise costs and source imported products, which would have an impact on local jobs.

Some stakeholders also noted that the proposed energy efficiency requirements would have an adverse impact on the competitiveness of steel-framed buildings relative to timber-framed buildings. The proposed energy efficiency requirements will introduce additional costs for steel-framed buildings to mitigate thermal bridging issues, which was discussed in section 5.3.3. There was also a concern that there are limited products available that could address the thermal bridging issue that would also meet the combustibility requirements.

9.3 Effects on small business

A number of stakeholders consulted for this project identified that the proposed energy efficiency requirements may have a disproportionate impact on small businesses compared to large businesses.

Firstly, large businesses were considered to be better placed than small businesses to transition to the new energy efficiency requirements. Large businesses have dedicated technical and R&D staff to review and apply the new requirements to their businesses, while small businesses are often family-owned without access to dedicated technical expertise.

Large businesses are then able to recover the costs associated with implementing the new standards across a larger number of builds than smaller businesses, reducing the incremental cost per build.

[263] AAC 2017, *Multiple Impacts of Household Energy Efficiency: an Assessment Framework*, report to Energy Consumers Australia, October, https://www.acilallen.com.au/projects/energy/multiple-impacts-of-household-energy-efficiency-an-assessment-framework.

[264] Kenington, D., Wood, J., Reid, M., & Klein, L. 2016, *Developing a Non-Energy Benefits Indicator Framework for Residential and Community Energy Efficiency Programs in New South Wales*, Australia, International Energy Policies & Programmes Evaluation Conference. Amsterdam

[265] GEER Australia 2017, *Power Shift Project Two Deliverable 1: Overview of Energy Efficiency Co-Benefit*, Group of Energy Efficiency Researchers Australia.

Large businesses were also considered to have stronger buying power that enabled them better access to supplies at a lower cost. This was considered to be a particular advantage in the current COVID-constrained environment with constraints in the supply chain.

9.4 Impacts on consumer choice and property rights

Stakeholders consulted for this project were of the view that the proposed energy efficiency requirements in the NCC 2022 will have an adverse impact on consumer choice. Consumers can currently choose whether to comply with the current energy efficiency requirements or to over-comply, by trading off, for example, costs, amenity and housing supply. However, if the energy efficiency requirements are more stringent, then the ability to exercise this choice is more limited.

Some stakeholders were of the view that there would be an incentive for a small solar PV system with a small inverter to be installed. The small inverter would then limit a consumer's flexibility to upgrade the size of the solar PV system at a later point in time. However, other stakeholders were of the view that there would be an incentive to install a large solar PV system.

9.5 Equity issues

Stakeholders noted that it would be easier to meet the minimum 7 star standard in mild climates (such as Sydney) and warmer climates (such as Brisbane) than in cooler climates (such as Melbourne, Canberra and Hobart). The costs to meet the minimum 7 star standard would therefore be lower in the mild and warmer climates than in the cooler climates and this may ultimately make it more difficult to secure financing for a new home in the cooler climates and price first home buyers out of the new housing market.

9.6 Unintended consequences

A number of additional unintended consequences associated with the proposed NCC 2022 energy efficiency requirements were identified through consultations with stakeholders. These are discussed in the following sections.

9.6.1 Impacts on buildings

Stakeholders were concerned that the proposed energy efficiency requirements would have an adverse impact on building outcomes, building amenity and ventilation within the building.

Impact on building outcomes

To meet the proposed more stringent energy efficiency requirements, there may be an incentive for builders to save costs by installing, for example:

— water heaters that are too small, so the occupants do not have sufficient hot water for their needs

- space heating or cooling that is too small, resulting in the occupants installing additional equipment that may not be as efficient at a later point in time
- a larger solar PV system so that less energy efficient equipment can be installed, depending on the relative cost of the solar PV system and the equipment.

A specific issue was raised in relation to the proposed verification method for Class 2 SOUs, which may lead to adverse outcomes for Class 2 buildings. The proposed verification method does not impose any backstops for thermal comfort or minimum performance. It requires that the heating and cooling loads of each SOU in the proposed building to be better than the heating and cooling loads for the corresponding SOU of the reference building. As a result, poorer outcomes (potentially below current minimum compliance levels) generated within some units within the reference building are extended to the proposed building by design, and may result in significant disparities in thermal performance between individual units.

The NCC is:

> … a performance-based code containing minimum necessary requirements to efficiently achieve safety, health, amenity, accessibility and sustainability through the design, construction, performance and liveability of new buildings and new work on existing buildings throughout Australia.[266]

There is a trade-off between the objectives of the NCC. One of the stakeholders commented that buildings that met the sustainability objective by producing zero net emissions may not meet the proposed energy efficiency requirements in the NCC 2022 because they did not meet the minimum 7 star requirement for the building shell.

Impact on building amenity

Three examples of the potential adverse impacts of the proposed energy efficiency requirements on building amenity were identified:

1. Windows – as glazed elements of the building fabric dominate heat gain and loss, the more stringent requirements may lead to smaller windows which provide less natural light and less overall amenity for occupants.
2. Lights – as the energy efficiency requirements are based on an energy use budget that assumes 4 Watts of lighting per square metre, downlights may be installed in preference to decorative or architectural lighting.
3. Accessibility – the requirement for a raised slab to meet the energy efficiency requirements may conflict with the accessibility requirement for step-free access to the building.

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[266] Australian Building Codes Board (ABCB) 2019, Energy Efficiency: NCC 2022 and beyond Scoping study, July, https://consultation.abcb.gov.au/engagement/energy-efficiency-scoping-study-2019/.

Ventilation

There is a relationship between the insulation of a building and the thermal comfort of a home. As identified by the Energy Efficiency Council and the Australian Sustainable Built Environment Council:[267]

> Insulating materials play a key function in maintaining a safe and comfortable indoor temperature, but can also influence air movement, air quality, moisture and the presence and absence of mould.

The thermal performance of a building is also impacted by air leakage. However, excessive air tightness can result in condensation and poor air quality, including high levels of carbon dioxide. Modern building practices combine minimising unintended air leaks with designing effective ventilation systems to ensure an appropriate level of airflow through a building. Ventilation strategies also have a critical impact on moisture level.

Stakeholders were concerned that the more stringent energy efficiency requirements for the NCC 2022 may result in poor ventilation with resultant issues associated with condensation and poor air quality. The ABCB is currently separately investigating this issue and changes are being proposed to ensure condensation risks are not increased.

Increased fire risk

As discussed in section 9.2, the thermal bridging issue may be mitigated using combustible foam insulation products in walls and roofs, which will increase the fire risk. This will particularly affect Class 1 buildings in designated bushfire risk areas.

Issues associated with solar PV systems

Stakeholders raised a number of potential issues associated with the installation of solar PV systems on rooftops, including the potential for:

— poor quality of solar panels, which may crack
— rain ingress associated with the solar panel installation
— issues relating to the additional weight on the roof
— solar panels dislodging during wind events
— fire starts.

Additionally, solar PV systems may be installed as a means to meet the NCC 2022 requirements, but may not be able to:

— produce energy due to shading, in which case, the costs are incurred for little benefit
— export energy due to constraints in the network, reducing the benefits associated with the system.

[267] Energy Efficiency Council and Australian Sustainable Built Environment Council 2021, *Ensuring quality control and safety in insulation installation: A research report to support an industry-led roadmap for healthy, comfortable buildings.*

Stakeholders were of the view that the solar PV system should be sized appropriately for the circumstances associated with each particular building, to ensure an efficient outcome.

Lastly, stakeholders noted that there is a requirement to install the solar PV system but not a requirement to use the solar PV system. As a consequence, the benefits associated with the installation of the solar PV system may not be realised.

To address the issues associated with installing solar PV systems, and the difficulty of installing solar PV systems for Class 2 buildings, one stakeholder queried whether solar PV systems should be installed at the precinct level. This may be an option where a developer builds houses in a new estate or builds a block of units, but raises a range of issues that would need to be addressed related to the ownership and long term operation and maintenance of the solar PV systems, and the ability to monitor and enforce compliance with the requirements in the NCC 2022.

It is also not a practical solution for renovations or new buildings in established suburbs, unless a company established a business model to specifically address that need.

Impact of thermal bridging requirements on steel industry

During consultation, the HIA raised concerns with the proposed introduction of thermal bridging requirements, particularly in regard to the impacts that the proposed thermal bridging provisions would have on the steel framing industry (HIA argues that builders will re-consider their choice of framing system if one would face additional costs over the other).

9.6.2 Impacts on consumers

Stakeholders commented that the proposed energy efficiency requirements in the NCC 2022 may encourage the building of houses with no eaves and dark coloured roof and walls. This would reduce the resilience of the building to extreme weather conditions in some climate zones, and particularly impact occupants that cannot afford to purchase or operate an air conditioning system.

Some stakeholders queried whether the installation of solar PV systems may result in increased, rather than decreased, energy use. This may be because the solar PV system allows less energy efficient equipment to be installed (as discussed in the section above) or because of behavioural choices by the occupants with energy supplied by a renewable source. The CBA has included a 10 per cent rebound factor to allow for these effects, but in reality, the rebound factor could be higher.

Concerns were also raised that the requirement to meet the proposed energy efficiency requirements in the NCC 2022 may slow down the rebuild of homes in bushfire affected areas due to the availability of materials required to meet the minimum 7 star standard.

9.6.3 Impacts on industry

A number of stakeholders were concerned about the complexity of the proposed energy efficiency requirements in the NCC 2022, noting that the energy efficiency requirements are the most complex part of the NCC. The Housing Industry Association commented that it is still receiving calls seeking clarity around the 6 star requirements. Industry is likely to require assistance to support them in the transition to the more stringent requirements.

The industry will need input from assessors earlier in the design process to ensure compliance with the requirements. Notwithstanding, the increase in the complexity of the energy efficiency requirements may increase the risk of non-compliance.

One stakeholder queried whether the solar PV industry would have the capacity to install the number of solar PV systems required under the proposed NCC 2022. As illustrated in Figure J.8, the additional solar PV capacity that is estimated to be installed as a result of the proposed NCC 2022 requirements is relatively small relative to the baseline, other than in Victoria when the current Solar Homes Program concludes. The solar PV industry in all states other than Victoria is likely to be able to readily absorb the additional capacity required.

The additional solar PV capacity to be installed in Victoria under the proposed NCC 2022 is high relative to the baseline when the current Solar Homes Program concludes. The installations under the NCC 2022 will absorb some of the excess capacity in the industry following the conclusion of the Solar Homes Program.

9.6.4 Impact on the electricity grid

The estimated impacts of the proposed energy efficiency requirements on the wholesale energy market are discussed in section 7.5. However, there may also be impacts on the electricity grid, particularly at the distribution level.

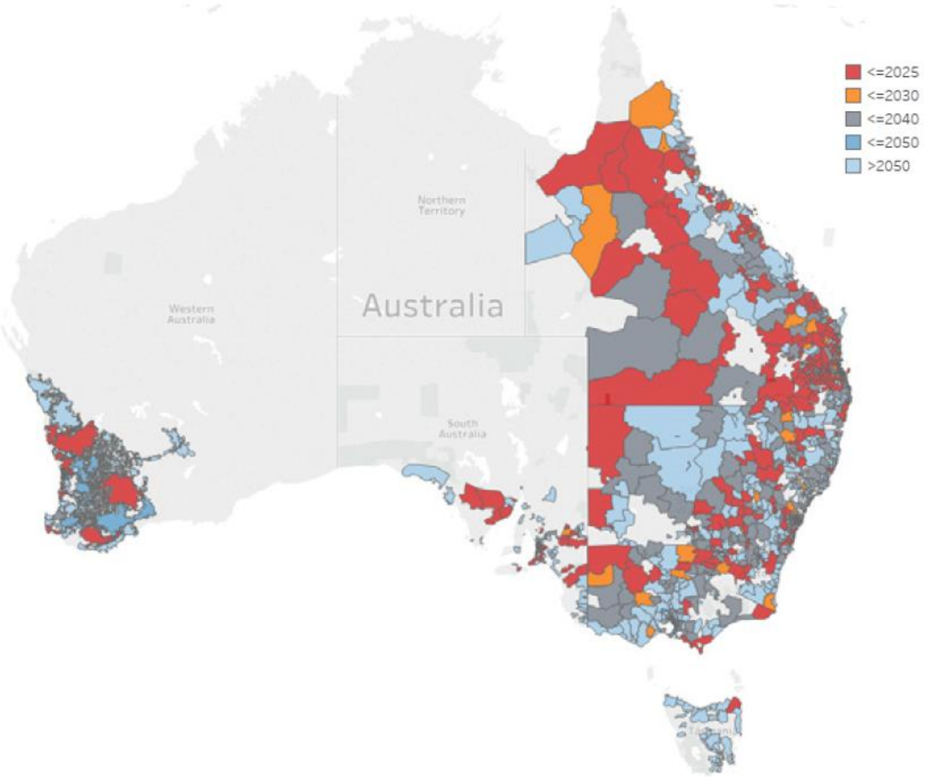
The CSIRO has identified that zone substations can accommodate up to about 40 per cent of their total annual load from solar PV. It has projected, for each postcode in the National Electricity Market and the Western Australian Electricity Market, the decade in which the threshold penetration is exceeded under two different scenarios – a slow Distributed Energy Resources (DER) uptake scenario and a fast DER uptake scenario, see Figure 9.2.

When the threshold is exceeded, either investment will be required in the network to manage the consequences, and/or households will be constrained from exporting energy from their solar PV system. Our discussions with stakeholders indicated that it is more likely that there will be some form of constraint on the energy that is exported, either through export limits or cost reflective pricing to incentivise efficient outcomes.

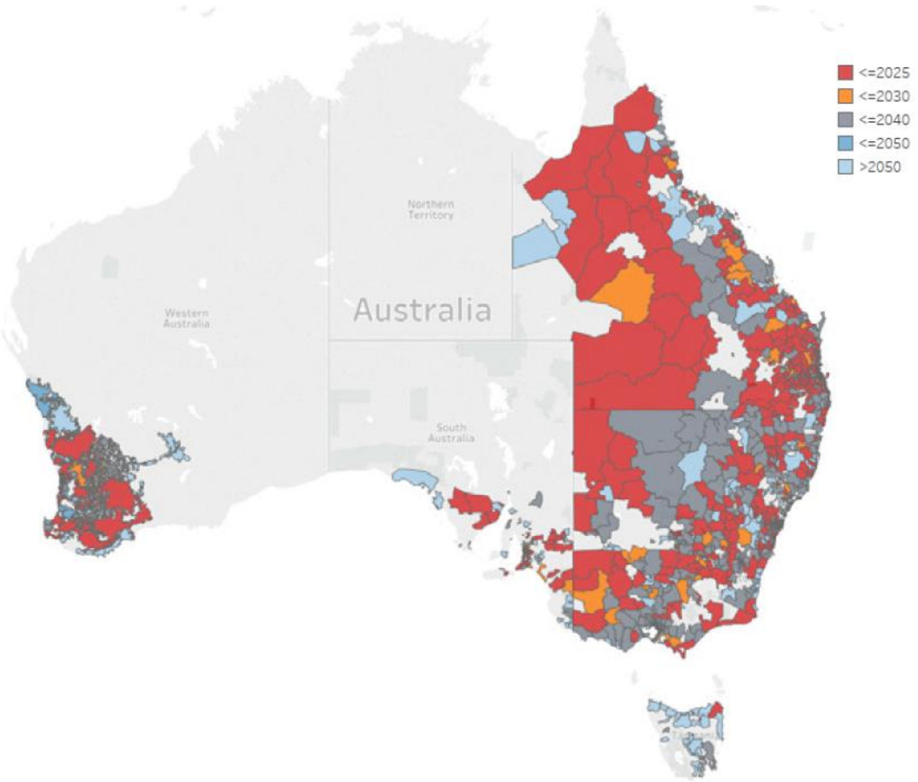
As illustrated in Figure 9.2, the penetration of solar PV systems will exceed the threshold penetration in a number of postcodes by 2025, in particular in regional areas, more so under the fast DER uptake scenario than the slow DER uptake scenario. Stakeholders also identified there is limited capacity for additional solar PV systems in Queensland, South Australia and Victoria (as a result of the Government’s 10 year Solar Homes program).

Figure 9.2 Projected decade in which Australian postcodes will reach a threshold penetration of rooftop solar adoption (40 per cent)

Slow DER uptake scenario



Fast DER uptake scenario



Source: Energy Networks Australia 2019, Open Networks Australia, Position Paper.

As illustrated in Figure J.8, the additional solar PV capacity that is estimated to be installed under the proposed energy efficiency requirements for the NCC 2022 is a relatively small proportion relative to the new solar PV capacity that is forecast over the next decade. The distribution network will become more constrained over the next decade with or without the proposed energy efficiency requirements for the NCC 2022. The proposed requirements may bring forward the date by when the network becomes constrained, but will not make a material difference.

The amount of solar PV capacity that is estimated to be installed assumes that excess energy will be exported. The revenue from the export of energy is a benefit to the household. However, if the exports are constrained, then:

— as discussed in 5.5.2, additional measures would have to be taken to achieve savings equivalent to 30 per cent of the societal cost of the benchmark building specified in Option B
— the benefits to the household will be lower than estimated in the distributional analysis.

9.6.5 Impact on gas usage

Stakeholders had a range of views in relation to the impact of the proposed energy efficiency requirements in the NCC 2022 on gas usage, depending on their perspective.

On one hand, some stakeholders were concerned that the proposed energy efficiency requirements disadvantaged the use of gas equipment relative to electrical equipment, which would provide a disincentive to extend gas to new developments.

On the other hand, some stakeholders were of the view that there should be no incentive for gas equipment to be installed as some governments are considering phasing out gas usage[268] and gas equipment is not able to use the energy that is produced by the solar PV system.

The proposed energy efficiency requirements in the NCC 2022 are technology neutral. The decision as to whether new gas equipment is or is not installed in a new building will depend more on other policy decisions by governments than the requirements in the NCC 2022.

[268] For example, one of the goals in the *ACT Climate Change Strategy 2019-25* is to reduce emissions from gas by removing the mandate to reticulate gas in new suburb, conducting a campaign to support the transition from gas to electricity and setting out transition periods for phasing out new and existing gas connections.

10 Implementation and review

10.1 Implementation of the proposed changes

If either one of the proposed policy options is approved for implementation, the two existing Performance Requirements relating to residential energy efficiency in Volume Two will be substantially modified for NCC 2022. To reflect the status of the Performance Requirements as the legal requirements of the NCC, each Performance Requirement will be written in a clear, objective and quantified manner. Practitioners will be able to comply with each Performance Requirement using a Performance Solution, without referring to the associated Verification Methods or DTS Provisions, although those approaches will also remain available.

The residential energy efficiency Verification Methods and DTS Provisions in NCC 2022 will be benchmarked against the Performance Requirements. Each method will be set so that it meets the level of performance specified in the Performance Requirements to within an acceptable degree of variation.

Notably, the substitution of qualitative Performance Requirements (which can discourage practitioners from using them for Performance Solutions) for quantified energy efficiency Performance Requirements is expected to:

— provide clarity on the expected compliance requirements and reduce the risk of misinterpretation of the requirements
— provide objective levels of performance for practitioners to target
— increase the use of Performance Solutions
— ensure that the minimum required level of performance is achieved.

The NCC is given legal effect by relevant legislation in each state and territory. This legislation prescribes or ‘calls up’ the NCC to fulfil any technical requirements that are required to be satisfied when undertaking building work.

If one of the proposed policy options is approved for implementation, the new requirements would replace the existing energy efficiency provisions in the NCC 2019, with jurisdiction’s regulations allowing for transition to new versions of the NCC. Implementation will ultimately be a matter for each state and territory to determine (states and territories can choose to apply the NCC 2022 provisions, with or without amendments). That is, the method of implementation is a matter for each state and territory according to the provisions of their own enabling legislation.

However, in the 2020 Intergovernmental Agreement that governs the operation of the ABCB, the Commonwealth, state and territory governments have committed to, as far as practicable:

1. reduce or validate variations to the NCC in its legislation
2. restrict making a restriction from the NCC, unless:
   a) there is a net benefit as evidenced by a Regulatory Impact Assessment
   b) the variation is approved by the relevant Minister
3. identify variations from the NCC and the on-adoption of NCC amendments in their respective jurisdictions and report this to the ABCB on an annual basis
4. reduce, restrict or validate local government or authorities where they have any administrative responsibility for regulating building and construction interventions to the NCC.[269]

The administration and enforcement of the NCC is also ultimately the responsibility of individual states and territories, and hence detailed implementation and compliance strategies cannot be explored in this RIS.

As a matter of policy, proposed changes to the NCC are released in advance of implementation to allow time for familiarisation and education, and for industry to modify its practices to accommodate the changes. It is anticipated that state and territory building administrations and industry organisations, in association with the ABCB, will also conduct information and awareness raising practices.

To assist with the implementation of the policy, the ABCB is developing a range of guidance materials, including factsheets, design solutions, case studies and calculators. Webinars are also planned to explain the changes to industry.

10.2 Review and evaluation

If one of the proposed policy options is approved for implementation, the revised minimum energy efficiency standards for residential buildings would be subject to review in the same way as any provision in the NCC. The ABCB allows interested parties to initiate a Proposal for Change (PFC) process to propose changes to the NCC.[270] This is a formal process which requires proponents of change to provide justification to support their proposal. This justification should be proportionate to the size of the proposed change or its potential impacts and should include:[271]

— a description of the proposal
— an explanation of the problem it is designed to resolve
— evidence of the existence of the problem
— how the proposal is expected to solve the problem

[269] Available at https://www.abcb.gov.au/sites/default/files/resources/2020//2020_ABCB_IGA.pdf

[270] The PFC process relates to technical proposal to change the NCC. Technical proposals do not include those which address matters of public policy or for which direction from government is required before a change to the NCC can be considered.

[271] ABCB 2021, *Propose a change page, https://ncc.abcb.gov.au/ncc-online/Propose-a-Change*.

— what alternatives to regulation have been considered, and why they are not preferred
— who will be affected and how they will be affected
— any consultation that has taken place.

PFCs are considered by the ABCB's Building Codes Committee (BCC) each time it meets. The role of the BCC, which consists of representatives of all levels of government as well as industry representatives, is to provide advice, guidance, and make recommendations relating technical matters relevant to the NCC. If the proposal is considered to have merit, the BCC may recommend that changes be included in the next public comment draft of the NCC, or for more complex proposals, it may recommend that the proposal be included on the ABCB's work program for further research, analysis and consultation.

This process means that, if the proposed minimum energy efficiency standards for residential buildings are found to be more costly than expected, difficult to administer or deficient in some other way, affected parties can initiate a PFC.

Additionally, to encourage continuous review and feedback, the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. In particular, a continuous feedback mechanism exists and is maintained through state and territory building control administrations and industry through the BCC. These mechanisms ensure that opportunities for regulatory reform are identified and assessed for implementation in a timely manner.

As with all other aspects of the NCC, the effectiveness and observed impacts of the proposed measures should be monitored. The analysis in this RIS has been undertaken based on the best information currently available and it will be necessary to verify how the building industry do in fact respond, particularly given the extensive changes being proposed. The ABCB will seek regular feedback from industry, building administrators, and other stakeholders in relation to the implementation of the new requirements.

11 Conclusion

Based on the analysis presented in this RIS, the preferred option to improve the energy efficiency of new residential buildings is applying Option A for Class 1 dwellings and Option B for Class 2 dwellings. While this combination of policies results in net costs to the Australian economy of $547 million and a BCR of 0.8, it is the preferred option when compared to the other options analysed (including applying either Option A or Option B to both dwelling classifications and the alternative options analysed in response to feedback on the CRIS) because:

— it provides the highest level of GHG emissions savings at the lowest net cost to the economy

— it is the regulatory option that results in the highest BCR at economy-wide level

— at a household level, it would deliver net benefits to households in both Class 1 and Class 2 dwellings in all jurisdictions (except households in apartments in Queensland)

— it helps meet the objectives of the regulation by reducing energy consumption, reducing GHG emissions, improving occupant health and amenity and improving the resilience of dwellings to extreme weather and blackouts

— it meets the criteria for recommending an option other than the one with the highest net benefit (in this case, the base case)[272], as this option:

  – is likely to deliver significant benefits that cannot be monetised

  – would provide higher resilience in the face of uncertainty

  – would provide significant benefits to new households, particularly to vulnerable households, in the form of energy savings

— compared to the alternative regulatory options analysed in response to feedback, it results in:

  – built-in efficiency as opposed to efficiency from non-fixed assets, which have shorter lifespans

  – improvements in thermal comfort

  – improved building resilience

  – improved outcomes for the electricity grid.

Notably, beyond the outcomes from the CBA, there are a number of other considerations that are important when making the decision about the stringency of NCC 2022, including:

— the value of unquantified (but well recognised) benefits to households of more energy efficient residential buildings, including improved social equity, amenity, health and wellbeing, and resilience to extreme weather events and in the event of power outages

— Australia's progress towards meeting national and international GHG emissions reduction commitments and the role that the proposed changes would play in achieving these targets

[272] Additional details of the decision rules for RISs are discussed in Box 1.2 in Chapter 1.

- the value the community places on further energy efficiency improvements in residential buildings
- the significant benefits for new households from energy savings, particularly to vulnerable households
- the historical precedent of approving an increase in energy efficiency from 5 to 6 stars in 2009 despite the final RIS estimating a net loss to the Australian economy from the proposed changes of $259 million (in 2009 dollars) and a BCR of 0.88.

Decision-makers are best placed to weigh up these factors against the net cost imposed on other members of the community.

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