ACIL ALLEN

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Report to Australian Building Codes Board

National Construction Code 2022

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

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Glossary

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
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
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
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CZ	Climate Zone
DCCEE	Department of Climate Change and Energy Efficiency
DCF	Discounted cash flow
DISER	Department of Industry, Science, Energy and Resources
DTS	Deemed to Satisfy
E3	Equipment Energy Efficiency
EES	Energy Efficiency Strategies
ESOO	Electricity Statement of Opportunities
GEMS	Greenhouse and Energy Minimum Standards
GWh	Gigawatt hours
HIA	Housing Industry Association
HSPF	Heating Seasonal Performance Factor
IGA	Inter-Governmental Agreement
ISP	Integrated System Plan

kWh	KiloWatt-hour
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
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
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
SIPS	System Integrity Protection Scheme
SOU	Sole occupancy unit
SRMG	Short Run Marginal Cost
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
WoH	Whole of House

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*. Its purpose is to inform and seek feedback from interested parties regarding a proposal to amend existing regulatory requirements for energy efficiency in residential buildings. 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 this Consultation Regulation Impact Statement (RIS) assessing the costs and benefits of proposed increases in energy efficiency requirements in the NCC 2022 for new residential buildings. 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).[1]

The report is intended to assist a wide range of stakeholders to provide feedback to the ABCB on the proposed changes to the NCC. This RIS will be updated to incorporate relevant information and data gathered through the consultation process on the analysis and updates as a result of ongoing work on technical proposals[2] as a Final RIS used by the ABCB as an input into its decision making.

The residential buildings covered in this RIS analysis are new Class 1 and Class 2 sole occupancy units.

Statement of the problem

The residential building sector is a major source of energy demand and use. It currently accounts for approximately 7.4 per cent of Australia's energy use (across all fuels)[3], around 29 per cent of electricity use and is responsible for around 11 per cent of Australia's greenhouse gas emissions[4].

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

[2] The ABCB is undertaking consultation on technical proposals separately. For more information on the NCC 2022 public comment draft see www.abcb.gov.au.

[3] Department of the Environment and Energy 2019, *Australian Energy Statistics*, September.

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

In 1974 the annual residential energy sector consumption was about 231 petajoules (PJ). By 2018 this had grown to about 459 PJ. This represents a 98 per cent increase in residential sector energy consumption over the period.

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 the residential building sector 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[5]) associated with energy consumption which result in energy prices that do not fully reflect the cost of consuming energy (which includes the cost of greenhouse gas 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:
  – Australia's Nationally Determined Contributions under the Paris Agreement that set an economy-wide target to reduce greenhouse gas emissions by between 26 and 28 per cent below 2005 levels by 2030. Australia has stated that it is aiming to overachieve on this target and that it aims to reach net zero emissions as soon as possible, preferably by 2050
  – various commitments by States and Territories to net zero emissions by 2050

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um%20-%20Report%20for%20Achieving%20Low%20Energy%20Existing%20Homes_1.pdf, accessed 28 September 2020.

[5] Externalities exist when the welfare of some agent, or group of agents, depends on the activity of another. When the effects of one economic agent on another are not taken into account, market prices will not reflect the true marginal cost/benefit of the good or service traded. In the case of energy, negative externalities associated with consumption result in energy prices that do not reflect the full cost of consuming energy (which includes the cost of greenhouse gas emissions and the costs associated with peak demand). This results in higher energy consumption than socially optimal and in lower investment in energy efficiency measures.

  - 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 the residential building sector. 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
- the current energy efficiency requirements in the NCC having remained at the current level of stringency for 10 years. As noted by the former COAG Energy Council, it is important to consider updating them 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'[6]
- 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
- support by some industry groups for further energy efficiency improvements in residential buildings, particularly through the NCC
- the significant benefits that energy savings can provide to households, particularly to vulnerable households.[7]

Objectives

The stated objective of the energy efficiency requirements in the NCC is to reduce greenhouse gas 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
- reduce greenhouse gas emissions
- improve occupant health and amenity
- improve the resilience of a building to extreme weather and blackouts.

[6] 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.

[7] 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).

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 international commitments, various commitments by States and Territories to net zero emissions by 2050 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.[8]

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

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 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 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 B 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), and the Board of the ABCB, which includes industry representatives.

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

The policy options formally considered under this RIS which are intended to apply to new residential 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[9]) 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 Nationwide House Energy Rating Scheme (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 PV).

— **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 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.

[9] 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/).

[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.

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).[12]

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

— the Deemed to Satisfy (DTS) provisions
— NatHERS
— 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.

Non-regulatory options

The RIA Guidelines require that a RIS identifies a range of viable options, including, as appropriate, non-regulatory, self-regulatory and co-regulatory options.[13] 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 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 sector, 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 but also the Commercial Building Disclosure (CBD) Program, and Minimum Energy Performance Standards and energy labelling for equipment).

[12] Trading between the thermal shell and appliances will not be possible when using the Deemed to Satisfy (DTS) elemental compliance pathway.

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

Estimated impacts

The estimated impacts of the proposed policy options are presented in Table ES 1. Costs and benefits have been expressed in both Net Present Value[14] (NPV) terms in 2021 dollars (in millions), and as Benefit Cost Ratios[15] (BCRs). The costs and benefits that have been quantified in the analysis 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 by the sample of dwellings modelled and deferred network investment for gas and electricity as a result of reductions in peak electricity demand and reductions in 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, since the removal of Australia's carbon pricing mechanism in 2014, there is no universally agreed transparent price which can be assigned to these emissions.
  - **Health benefits from reduced electricity and gas generation and use** — these are benefits from reduced pollution from electricity and gas generation. While it is clear that electricity generated from fossil fuels 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 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[16]
  - 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 (such as training costs).

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.

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

[15] The BCR is calculated by diving 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.

[16] 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.

Section 8.1 discusses how these types of benefits are largely captured and more substantial when comparing the proposed energy efficiency provisions in the NCC 2022 with older building stock.

Reflecting the level of certainty of different benefits discussed above, the NPV and BCR metrics in Table ES 1 are presented incrementally by adding benefits from the most certain to the least certain.

Table ES 1 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 network investment are used as a proxy), which as noted in Chapter 7, 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.

Table ES 1 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Australia

	Option A	Option B
COSTS		
Households - capital (resource) costs	3,392.8	2,306.8
Industry	65.2	65.2
Government Costs	0.6	0.6
TOTAL COSTS	**3,458.6**	**2,372.6**
BENEFITS		
Households		
Electricity savings	454.4	62.4
Gas savings	349.5	394.9
LPG and firewood savings	30.7	31.1
Household subtotal	**834.5**	**488.4**
Society		
Deferred network investment for gas and electricity	62.6	5.9
Greenhouse emissions savings	195.3	83.1
Health benefits from improved air quality	119.6	12.5
Society subtotal	**377.6**	**101.5**
TOTAL BENEFITS	**1,212.1**	**589.9**
NET PRESENT VALUES		
Accounting for energy benefits only	**-2,561.5**	**-1,878.3**
Accounting for energy benefits + carbon benefits	**-2,366.1**	**-1,795.2**

	Option A	Option B
Accounting for energy benefits + carbon benefits + health benefits	**-2,246.6**	**-1,782.7**
BCR (RATIO)		
Accounting for energy benefits only	0.26	0.21
Accounting for energy benefits + carbon benefits	0.32	0.24
Accounting for energy benefits + carbon benefits + health benefits	0.35	0.25

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Sensitivity and breakeven analysis

Given the uncertainty associated with many of the assumptions used in the cost benefit analysis, 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 4 and Appendices F and G):

— discount rate
— industry costs
— carbon prices
— rebound effect
— energy savings achieved in practice.

The BCR increases with a reduction in the discount rate, a decrease in industry costs, an increase in the carbon price, a reduction in the rebound effect and an increase in the energy savings achieved in practice. However, substantial changes to each of the assumptions were not sufficient to result in a BCR of one (or a positive net present value).

Breakeven analysis was also undertaken, which indicates that there would need to be a very significant increase in wholesale energy costs (more than three times) and/or a very significant reduction in the capital costs (a discount of around 70 to 80 per cent) for there to be an Australia-wide net societal benefit associated with the proposed policy options.

Energy market impacts

Concerns have been raised regarding the impact on the wholesale energy market (and the network) of the proposed increased uptake of solar PV. 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), any changes in capacity in terms of new investments or retirements of existing generators, and on minimum demand levels.

The key findings of this analysis are as follows:

- Capacity of solar PV systems installed – the amount of solar PV capacity estimated to be installed under the proposed NCC 2022 (option A) is low relative to the amount of solar PV capacity that will be installed under the BAU.
- Impact on electricity prices – the proposed NCC 2022 is projected to reduce wholesale electricity prices by up to 11.0 per cent to 2050 under option A as a result of the decrease in demand for electricity and increase in solar PV systems installed. The estimated reduction in retail electricity prices is approximately 25 per cent of the reduction in wholesale electricity prices, that is, up to around 2.7 per cent to 2050.
- Impact on generator capacity and output — the wholesale energy market modelling does not project any change in generator capacity with the proposed NCC 2022, and is not projected to bring forward coal-fired power station closures.
- Impact on minimum demand – the minimum demand in the NEM jurisdictions, other than South Australia and Victoria, is projected to be positive under the proposed NCC 2022. The proposed NCC 2022 is projected to bring forward negative minimum demand levels in South Australia by one year (from 2025 to 2024), and in Victoria to 2030 (under option A) or 2029 (under option A when assuming twice as much solar capacity is installed). The minimum demand levels in Victoria are projected to be negative in 2040 for around 10 hours under option A and around 20 hours if twice as much solar capacity is installed than under option A.

Distributional impacts

As is standard practice, the impact analysis 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 ES 2 shows the estimated energy bill savings[17] 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[18] (in present value terms). The effect on these households is measured using retail energy costs, rather than wholesale energy costs and avoided 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.

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

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

The estimated impacts in Table ES 2 show a more positive result for households than those results in Table ES 1 (which show the impacts on individual dwellings from a societal perspective — i.e. measured using wholesale energy prices and avoided network investment). However:

— Under Option A, the proposed changes are estimated to still result in net costs for most households in both Class 1 and Class 2 dwellings across Australia. That is, the benefits received by households in these dwellings from the additional energy efficiency measures installed are not sufficient to cover the additional costs incurred to implement these measures. Households in Class 1 dwellings in South Australia, Western Australia and the Northern Territory and in Class 2 dwellings in Tasmania and the ACT are estimated to experience net benefits from the proposed changes.
— Under Option B, the proposed changes are also estimated to result in net costs for most households in Class 1 dwellings in South Australia and Western Australia and households in Class 2 dwellings in Tasmania and the ACT.

Table ES 2 Estimated distributional impacts by household, $ per household (present value, $2021)

	Option A				Option B			
	Capital costs ($)	Energy bill savings ($)	Net bill savings ($, household NPV)	Household BCR	Capital costs ($)	Energy bill savings ($)	Net bill savings ($, household NPV)	Household BCR
Class 1								
NSW	3,243	2,463	-780	0.76	2,817	1,928	**-889**	0.68
VIC	4,356	3,013	-1,343	0.69	2,355	1,326	**-1,030**	0.56
QLD	979	630	-349	0.64	545	174	**-372**	0.32
SA	1,478	1,951	473	**1.32**	1,051	1,342	291	**1.28**
WA	1,045	1,422	377	**1.36**	951	1,263	312	**1.33**
TAS	3,402	2,961	**-441**	0.87	2,357	1,584	**-773**	0.67
NT	7,830	9,693	1,862	**1.24**	3,211	3,064	**-148**	0.95
ACT	2,292	2,200	**-91**	0.96	1,995	1,706	**-289**	0.86
Australia	2,547	2,026	**-521**	0.80	1,704	1,197	**-507**	0.70
Class 2								
NSW	2,855	1,812	**-1,043**	0.63	2,516	1,347	**-1,168**	0.54
VIC	4,226	1,521	**-2,705**	0.36	2,182	1,066	**-1,115**	0.49
QLD	3,834	1,861	**-1,973**	0.49	464	139	**-325**	0.30
SA	2,626	2,319	**-306**	0.88	2,626	2,319	**-306**	0.88
WA	3,000	1,468	**-1,532**	0.49	2,975	1,463	**-1,513**	0.49
TAS	2,269	3,128	859	**1.38**	1,809	2,452	644	**1.36**
NT	4,493	2,612	**-1,880**	0.58	2,174	1,382	**-792**	0.64
ACT	2,254	2,693	439	**1.19**	1,916	2,107	192	**1.10**
Australia	3,376	1,786	**-1,590**	0.53	2,051	1,132	**-919**	0.55

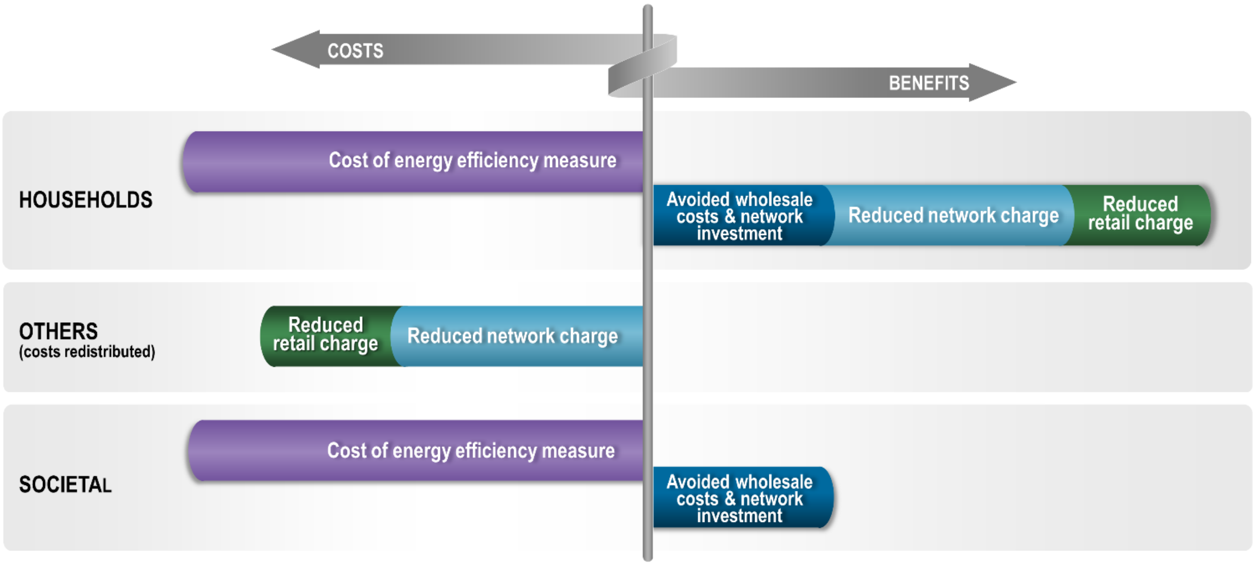
Note: these estimates use retail energy prices and refer to dwellings built in 2022. Present values calculated using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

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 costs and energy 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 ES 1.

Figure ES 1 Redistribution of costs and benefits



Note: The scale of impacts are illustrative only.
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 avoided network investment (as a proxy for avoided resource costs), which is why it is used in this 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. Because the impact analysis has to consider all net impacts, including these transfers, at the society level, a large part of the benefit to households must be offset in headline net present value results when assessing the policy overall.

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.[19]

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.

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, ie, reduction in network and wholesale costs.[20]

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. [21]

Conclusions

The analysis of the proposed policy options for more stringent energy efficiency requirements for new dwellings in the NCC 2022 indicates (based on the best available data and assumptions) that there would be a net societal cost for both options – the costs are estimated to outweigh the benefits by a significant margin. The capital costs associated with meeting the proposed energy efficiency requirements are estimated to be well in excess of the societal benefits that are largely derived from avoided resource costs in the energy sector (and which are estimated using wholesale energy costs and avoided network investment as a proxy).

While the analysis varies by option, by class of building and by jurisdiction, it is estimated that there would be a net societal cost for both Class 1 and Class 2 buildings and in each jurisdiction.

- The estimated BCR is higher for Class 1 buildings than for Class 2 buildings under both Option A and Option B.
- The estimated BCR is the highest in the Northern Territory under both policy options and the lowest:
  - under option A, for Class 1 and Class 2 buildings in Western Australia
  - under option B, for Class 1 in Queensland and Class 2 in Western Australia.

The breakeven analysis undertaken indicates that there would need to be a very significant increase in wholesale energy costs (more than three times) and/or a very significant reduction in

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

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

[21] Ibid, page 15.

the capital costs (a discount of around 70 to 80 per cent) for there to be an Australia-wide net societal benefit associated with the proposed policy options.

Even when considered from a household perspective, our analysis indicates that the estimated retail energy savings by the household do not exceed the capital costs associated with the proposed energy efficiency requirements:

— under Option A, for Class 1 buildings in New South Wales, Victoria, Queensland, Tasmania and the ACT and for Class 2 buildings in New South Wales, Victoria, Queensland, South Australia, Western Australia and the Northern Territory
— under Option B, for Class 1 buildings in New South Wales, Victoria, Queensland, Tasmania, Northern Territory and the ACT and for Class 2 buildings in New South Wales, Victoria, Queensland, South Australia, Western Australia and the Northern Territory.

The analysis over the expected life of the regulation using representative buildings and the assumptions outlined in Chapter 4 suggests that the total energy savings as a result of the proposal would be around 174 PJ under Option A and around 114 PJ under Option B, and 15.6 Mt CO2 (under Option A) and 6.6 Mt CO2 (under Option B) emissions avoided. However, our assessment suggests that improvements to occupant health and amenity and the resilience of a building to extreme weather and blackouts from the proposal would be immaterial.

Overall, the estimates presented in this RIS point towards the proposed changes to the NCC under both Option A and Option B imposing net costs across Australia (i.e. both options result in a negative economy-wide NPV).

The figures presented above are estimates based on the best information available at the time of the analysis, and assumptions have been used where data was not available. The purpose of this RIS is to seek stakeholder feedback on a number of important questions to inform the ABCB’s decision on whether the proposed energy efficiency provisions should be included in the NCC 2022. Some of these questions seek to gain more information that could be used in the Decision RIS to improve the estimates provided above.

Questions for stakeholders

The questions on which stakeholder feedback is sought are as follows:

Chapter 2: Statement of the problem

1. Does the RIS adequately identify and define the problem?
2. Are there any other problems not considered by this RIS?
3. Does the RIS establish a case for amending the energy efficiency provisions of the NCC?

Chapter 3: Objectives and options

4. Does the RIS present clear, well differentiated options for amending the NCC that can achieve the stated policy objective?
5. Which of the options analysed have the ability to meet the stated objectives? How could these be enhanced?

6. Are there any other feasible options to address the problems identified in the previous chapter that have not been assessed in the RIS and should be considered?
7. Of the options discussed in this chapter which would be the most effective at achieving the stated objectives and why?
8. Which is your preferred option?
9. What should the objectives of the residential energy efficiency provisions of the NCC be?

Chapter 4: Framework for analysis

10. Are there any assumptions or parameters used in the analysis that should be different? If so, is there alternative evidence that could be considered?
11. Should thermal bridging in timber-framed buildings be incorporated in the analysis? If so, how?
12. Is it reasonable to assume that industry's response to the proposed changes will be to select the lowest cost alternatives (e.g. installing PV, adopting high efficiency appliances or a combination of approaches) in every case?
13. How would industry most likely respond to the proposed whole-of-house changes under each of the proposed options?
14. How would industry most likely respond to the proposed thermal fabric changes under each of the proposed options?
15. In some cases, smaller windows are assumed to be used to constrain costs or achieve compliance with the proposal. Should the impact on occupant amenity be valued and how?
16. Does the use of a high efficiency equipment solution as a proxy for other non-modelled solutions over/under-estimate the costs of the proposed changes for Class 2 dwellings? If so, by how much?
17. Does the above proxy over/under-estimate the benefits for Class 2 dwellings? If so, by how much?
18. Is it practical to apply the WoH proposal to refurbishments?
19. How will the proposals be applied to refurbishments in practice?
20. Would the cost of applying the WoH proposal to renovations be broadly similar to the cost incurred in new dwellings?
21. Would the benefits resulting from applying the WoH proposal to renovations be broadly similar to the benefits received by new dwellings?
22. Are the assumptions used to estimate current and future penetration of solar PV in new buildings under the BAU appropriate and is there other evidence that could be considered?
23. Do you have any information that could be used to estimate the proportion of blocks for which solar PV could not be installed, i.e. those that are shaded and where solar PV could not be installed for Class 1 dwellings?
24. Do you have any information that could be used to estimate the proportion of Class 2 apartments for which sufficient solar PV could be installed to meet the energy use budget of each individual apartment?
25. As noted in this chapter, expected decreases in feed-in tariffs would effectively increase the stringency of the proposed WoH requirements under Option A over time. Do you have any views on this issue?

Chapter 5: Individual dwelling impacts

26. Are the cost estimates presented in this chapter reasonable? If not, what are your alternative estimates and the basis for those estimates?
27. Are the changes in energy consumption presented in this chapter reasonable? If not, what are your alternative estimates and the basis for those estimates?

Chapter 6: Economy-wide impacts

28. Can you provide estimates of the costs to redesign buildings and alter building products that would be incurred by industry to meet the proposed new NCC requirements?
29. Are there any other costs (e.g. transition costs) not identified for builders and other stakeholders in transitioning to the proposed new NCC requirements?
30. In terms of the realisation of the energy savings, which of the scenarios modelled is most likely to occur if the proposed changes are made to the NCC? What factors will affect the realisation of the modelled results?
31. Do you agree with the conclusions reached for the energy market impacts (relating to wholesale prices, generator capacity and minimum demand levels)?
32. Are there any other assumptions/parameters that should be included in the sensitivity/ breakeven analysis? If so, what values should be tested and why?
33. What is your view on the most appropriate value for avoided greenhouse gas emissions (carbon price)?

Chapter 7: Impacts on households

34. What are the implications of these findings for social equity and the problem of split incentives?

Chapter 8: Other impacts

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?
36. Can you provide objective evidence to enable any of the benefits that have not been quantified to be quantified?
37. Are there any other unintended consequences likely to arise from the proposed policy options?
38. Are there any other comments you would like to make in relation to the analysis in the RIS?

1 Introduction

As part of Paris Agreement[22], Australia has set an economy-wide target to reduce greenhouse gas 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.[23] 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 the residential building sector. Measures to improve energy efficiency in residential buildings in the NEPP include improving and expanding building ratings and disclosure, and advancing 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.

[22] 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.

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

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.

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).

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 Classes 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, to 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 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).

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/).

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).[24]

The RIS will be developed in two stages:

- a Consultation RIS for the purpose of consulting with interested stakeholders (this report)
- a Final RIS incorporating relevant information and data gathered through the consultation process with interested stakeholders. The Final RIS is used by the ABCB as an input into its decision on the matter that is the subject of the RIS.

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

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

1.4 Structure of this report

The remainder of this report is structured as follows:

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

Statement of the problem 2

2.1 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.

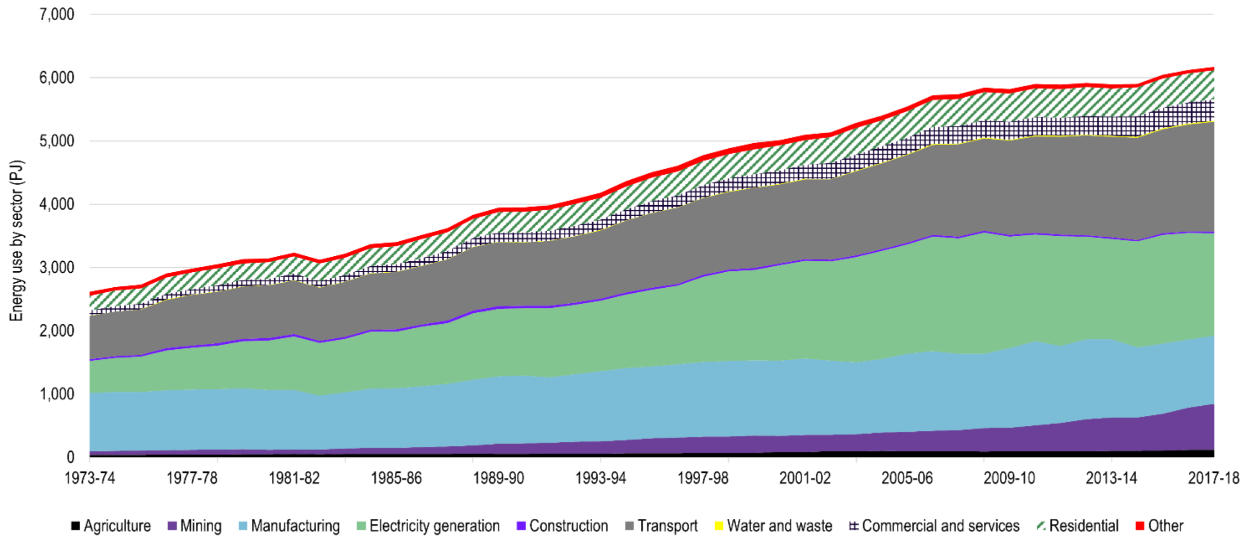
While the objectives of temperate houses and hot water are clear, the energy use required to achieve these objectives comes at a cost, both to those households and to society. At the household level, utility bills add to costs of living and can be a source of financial stress, especially for low-income households. Across society, residential energy use is a key source of energy demand, putting stress on the energy grid and generating greenhouse gas emissions.

According to the latest Department of Industry, Science, Energy and Resources data, the residential building sector is a major source of energy demand and use. It accounts for approximately 7.4 per cent of Australia's energy use (Figure 2.1). In 2017-18, this was 458.8 petajoules (PJ), about a third 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 1.4 per cent over the same period. This represents a 98.4 per cent increase in residential sector energy consumption over the period 1974 to 2018.

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 2.2), 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, the residential building sector is responsible for around 11 per cent of Australia's emissions and 29 per cent of electricity use.[25]

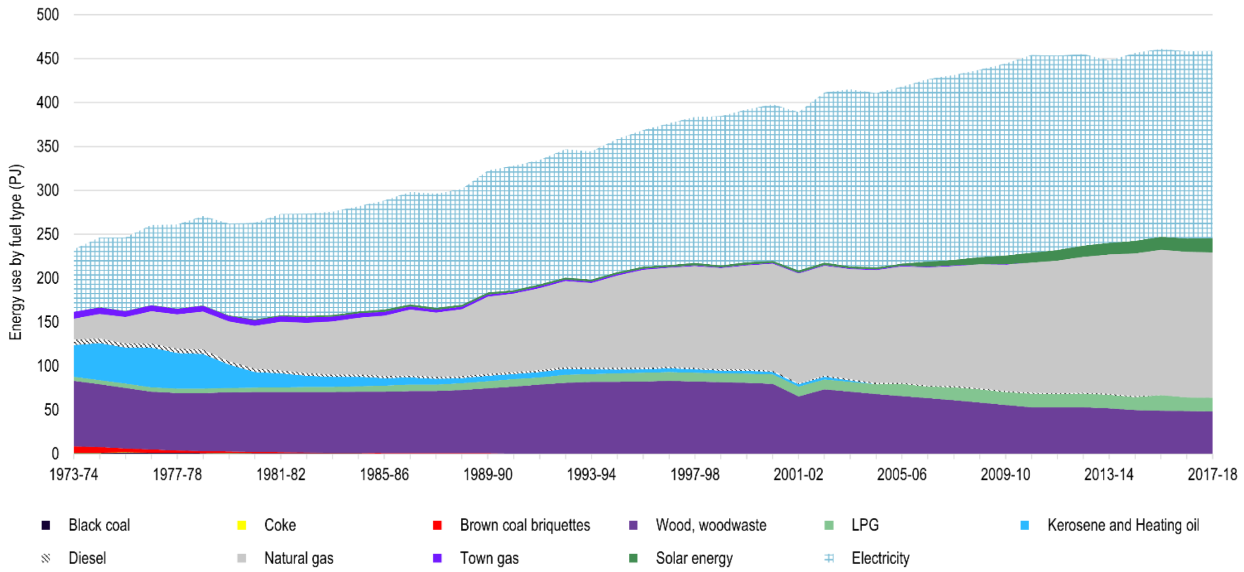
[25] COAG Energy Council 2019, Report for Achieving Low Energy Existing Homes, http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Trajectory%20Addendum%20-%20Report%20for%20Achieving%20Low%20Energy%20Existing%20Homes_1.pdf, accessed 28 September 2020.

Figure 2.1 Australian energy use, by sector, 1973-74 to 2017-18



Source: Department of the Environment and Energy 2019, Australian Energy Statistics, Table E, September.

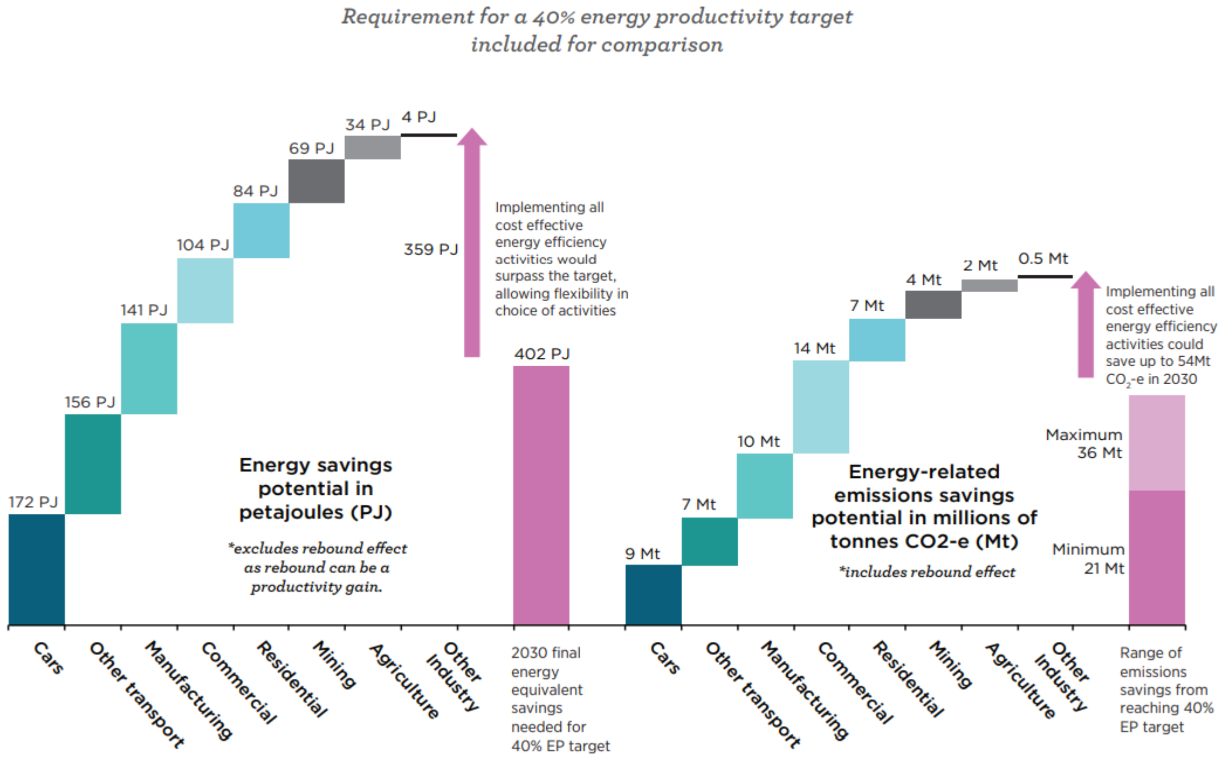
Figure 2.2 Residential energy use, by fuel type, 1973-74 to 2017-18



Source: Department of the Environment and Energy 2019, 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 the residential building sector 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 2.3).

Figure 2.3 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. Indeed, the Trajectory identified the following market failures that inhibit the ability of households to invest in energy efficiency measures within the residential sector: [26]

— **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

[26] 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 greenhouse gas 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.

2.2 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 2.1)

— 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 2.1 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, rebates are available for around 24,000 eligible households to install solar photovoltaic panels on their home. From 19 August 2018 eligible households will only have to pay 50 per cent of the cost of a solar panel system, up to a maximum rebate of $2,225. The rebate is available through Solar Victoria. In addition, a rebate of $1,000 for the purchase and installation of solar hot water systems is available for around 6,000 eligible households.
- $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

2.3 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.

2.3.1 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 greenhouse gas emissions by 26 to 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, and various commitments by States and Territories to achieve net zero emissions by 2050. 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.[27] 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 greenhouse gas abatement[28]

— the Victorian Government's commitment to improve the thermal performance of new residential buildings from 6 stars to 7 stars[29]

— 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 the residential building sector. 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.

2.3.2 Support by industry

Some industry stakeholders are supportive of further energy efficiency improvements. For example:

— The Australian Sustainable Built Environment Council (ASBEC, the peak body of key organisations committed to a sustainable built environment in Australia) in their report Built to Perform, an industry led pathway to a zero carbon ready building code30, call for a 'Zero Carbon Ready' building code and for the energy standards in the NCC to be 'urgently upgraded if new buildings are to be fit for a zero carbon future'.

— COAG's Report for Achieving Low Energy Homes noted that the majority of stakeholders consulted when developing this report (more than 250 stakeholders from a range of sectors) agreed that there needs to be stronger energy efficiency measures for Australia's residential buildings.31

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

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

[29] 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)

[30] Australian Sustainable Built Environment Council (ASBEC) 2018, *Built to Perform, an industry led pathway to a zero carbon ready building code*, July, https://www.asbec.asn.au/wordpress/wp-content/uploads/2018/10/180703-ASBEC-CWA-Built-to-Perform-Zero-Carbon-Ready-Building-Code-web.pdf, accessed 28 September 2020.

[31] 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. 43.

— In submissions received to the ABCB Scoping Study, Energy Efficiency: NCC 2022 and beyond many stakeholders 'attached high priority, and a sense of urgency, to the proposed changes to the NCC'[32] in the context of responding to climate change.

2.3.3 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).[33]

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 2.1). 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 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.[34]

[32] Australian Building Codes Board (ABCB) 2019, *Energy Efficiency: NCC 2022 and beyond Outcomes report,* p. 11.

[33] 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.

[34] 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.

Table 2.1 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 appliance 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 2.2[35], and upgrading appliances[36] 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 2.3.

[35] 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.

[36] 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 2.2 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 2.3, the AECOM analysis found that increased thermal performance and upgraded appliances 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 classes are separately analysed).

Table 2.3 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.

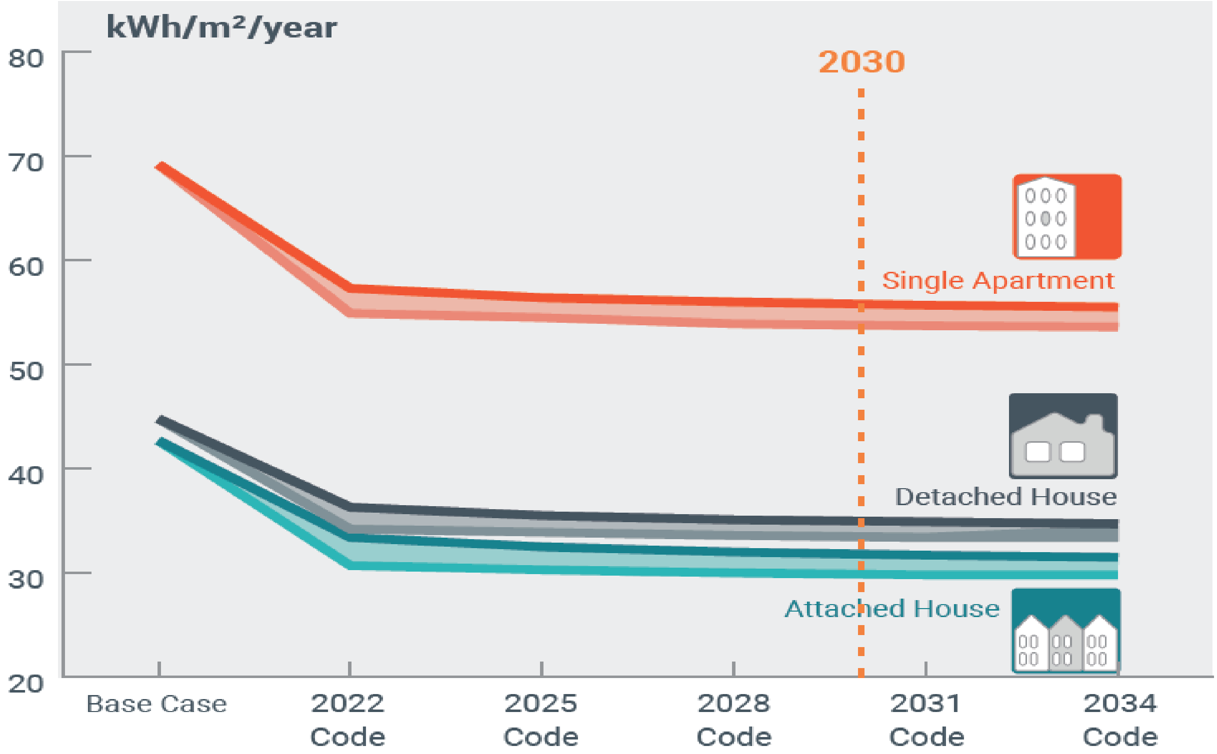
While the Trajectory modelling provided the basis for policy-making, the results from the modelling for the Trajectory are different to those for this RIS as the modelling was undertaken for a different purpose. The key differences between the two sets of modelling include:

— 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.
— 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, 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.
— 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 2.4) 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.

Figure 2.4 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

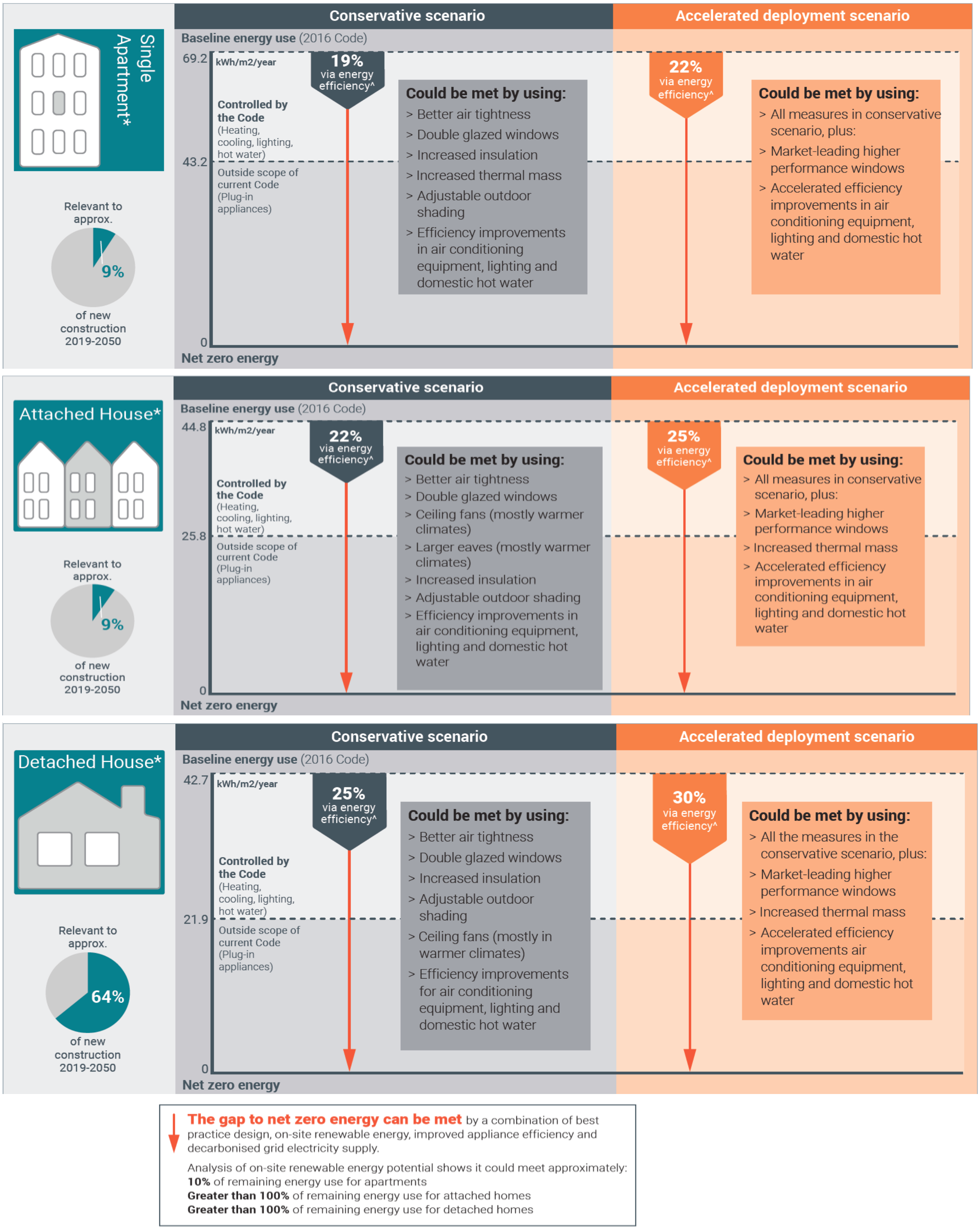
ASBEC's report found that (see Figure 2.5):

— 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 3.2 in the following chapter discusses why quasi-regulatory approaches are not a workable solution for this problem.

Figure 2.5 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

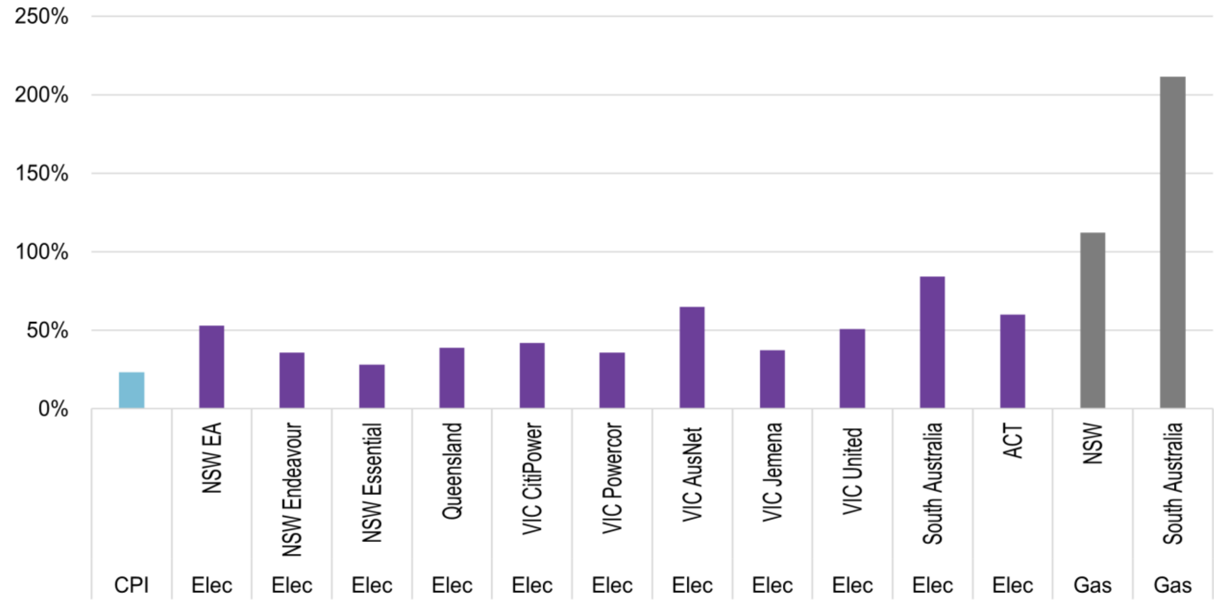
Source: Australian Sustainable Built Environment Council (ASBEC) 2018, Built to Perform, an industry led pathway to a zero carbon ready building code, July.

2.3.4 Market developments

Since the last increase to the energy efficiency requirements in the NCC for residential buildings eleven 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 2.6, 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[37]:
  – 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.
  – though electricity prices have plateaued towards the end of the period, and in the last few years have slightly fallen as renewable energy sources have begun to decrease wholesale energy costs.

Figure 2.6 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

— Decreases in the cost of energy efficient technologies — improvements in technology and falling prices have made energy efficiency measures more cost effective. For instance:

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

- The price of LED lights has fallen significantly over the years. In 2018 LEDinside[38] 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.[39] 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'.[40]
- 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.[41]
- In the last ten years, rooftop solar costs have fallen from above $2.50 per watt to around $1.00 per watt or less.[42]

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.

2.3.5 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.[43] 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.

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

[38] 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.

[39] 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.

[40] 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.

[41] Ibid.

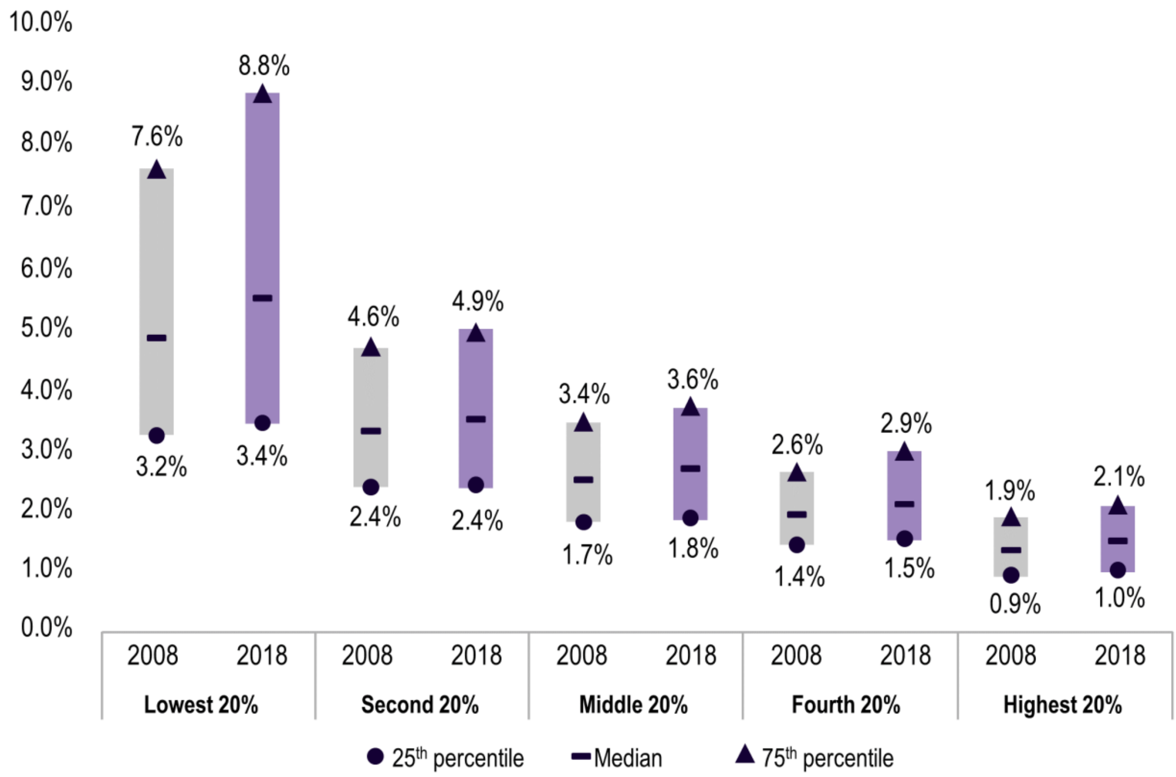
[42] Solar Choice 2020, https://www.solarchoice.net.au/.

[43] 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.

income on energy use.[44] Rising energy costs have exacerbated this trend, with cost increases proportionally affecting lowest-income households by a larger degree (see Figure 2.7).

Increasing energy efficiency standards for new residential buildings can reduce household bills.

Figure 2.7 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.

2.4 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 greenhouse gas emissions from energy consumption, informational barriers and split incentives

— recent policy commitments and directions

[44] 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.

- available evidence suggesting that there are significant opportunities to further improve the energy efficiency of new residential buildings cost effectively
- support by some industry stakeholders for further energy efficiency improvements in residential buildings, particularly through the NCC
- the benefits that energy savings can provide to households.

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.

2.5 Questions for stakeholders

1. Does the RIS adequately identify and define the problem?
2. Are there any other problems not considered by this RIS?
3. Does the RIS establish a case for amending the energy efficiency provisions of the NCC?

Objectives and options 3

3.1 Objectives of government action

Prior to 2010, the objective of energy efficiency requirements in the NCC was to reduce greenhouse gas 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 greenhouse gas 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
— reduce greenhouse gas emissions
— improve occupant health and amenity
— improve the resilience of a building to extreme weather and blackouts.

As discussed in Section 2.3.1, 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 various commitments by States and Territories to achieve net zero emissions by 2050
— 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: [45]

— 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 Verification Using Reference Building (VURB) pathway for Class 2 buildings.

3.2 Policy options

The objectives of the policies and commitments driving change 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. These are discussed in more detail in the sections below.

3.2.1 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.

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

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 greenhouse gas 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 4.

3.2.2 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[46]) for the elements of a building regulated by the NCC (space conditioning, heated water 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 (GEMS 2012) heat pump heater (Annualised Energy Efficiency Ratio, AEER = 4.5) [47]
— cooling equipment: equivalent to a 4.5 star rated (GEMS 2012) heat pump cooler (Annualised Coefficient of Performance, ACOP = 4.5) [48]
— 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.

[46] 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/).

[47] 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.

[48] 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.

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)[49].

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

- the Deemed to Satisfy (DTS) provisions
- NatHERS
- 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.

[49] Trading between the thermal shell and appliances will not be possible when using the Deemed to Satisfy (DTS) elemental compliance pathway.

3.2.3 Alternative 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.[50] 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 [51]
- 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 3.1)
- 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: [52]
  - 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

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

[51] 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.*

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

Box 3.1 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. [53]

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).

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.[54]

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

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[53] 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.

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

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 greenhouse gas emissions.[55]

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.[56]

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: [57]

— 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.

[55] 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.

[56] Ibid.

[57] 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.

The persistence of an energy efficiency gap (the difference between potential and actual energy efficiency in buildings, see discussion in Section 2.3.3) 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'. [58]

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.[59]

The Australian Government Best Practice Regulation Handbook (2007)[60] provides a checklist for the assessment of when quasi-regulation should be considered (Box 3.2). 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 3.2 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

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58 COAG Energy Council 2018, *Report for Achieving Low Energy Homes,* December, P. 1.

59 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.

60 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.

- 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.

Summing up

In light of the discussion above, the RIS does not formally analyse alternative 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 sector, 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).

3.3 Questions for stakeholders

4. Does the RIS present clear, well differentiated options for amending the NCC that can achieve the stated policy objective?
5. Which of the options analysed have the ability to meet the stated objectives? How could these be enhanced?
6. Are there any other feasible options to address the problems identified in the previous chapter that have not been assessed in the RIS and should be considered?
7. Of the options discussed in this chapter which would be the most effective at achieving the stated objectives and why?
8. Which is your preferred option?
9. What should the objectives of the residential energy efficiency provisions of the NCC be?

Framework for analysis 4

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 cost benefit analysis (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 Tony Isaacs Consulting (TIC)
— modelling of the impacts of the proposed Whole of House (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 photovoltaics (PV).

4.1 General CBA framework

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

4.1.1 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 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.

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 appliances are shorter-lived. In light of this, the following assumptions were used 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). The only exception to this is PV inverters which are treated as a 'package' with solar panels.

This approach to asset replacement is consistent with the approach used in other energy efficiency RISs and is considered appropriate for the assessment of the NCC requirements as once an appliance 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.

In summary, the costs and benefits are thereby modelled over a period of 40 years, with new buildings built over a ten year period and the benefits flowing from those buildings for a period of 30 years from the date of the new build.

4.1.2 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[61] have used these recommended discount rates, and HoustonKemp in their report *Residential Buildings Regulatory Impact Statement Methodology*[62] 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".[63]
- 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".[64]
- 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.[65]

To ensure compliance with OBPR's requirements and consistency of comparison with other economic analysis of energy efficiency measures in the NCC, we have used the OBPR's recommended discount rates for this RIS. 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).

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[61] 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.

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

[63] Ibid, p. 7.

[64] Ibid. p.7.

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

4.1.3 Cost benefit summary measures

The CBA model includes two summary measures that distil the results of the analysis, as described in Table 4.1.

Table 4.1 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.

4.1.4 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 Deemed to Satisfy (DTS) provisions
  – NatHERS
  – 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.[66]

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, 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.

4.1.5 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.

4.1.6 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.

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

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 House 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: [67]

— 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.

4.1.7 Interactions with state and territory legislation

While the NCC is a national code, states and territories can choose to apply its provisions, with or without amendments. 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 a lower or different star rating, for instance:

— 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 achieve as much as 1.5 stars less than the national minimum requirement where an outdoor living area and solar PV is installed; or a Class 2 building to achieve an average of 1 star less than the minimum national requirement.

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 policies. The analysis assumes that each of the states and territories will apply the NCC in its jurisdiction and compares the current NCC national requirements to the proposed new requirements.

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. 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 a 6 star NatHERS rated dwelling to 7 stars plus meeting the required societal cost of operating the building under each policy scenario (i.e. the WoH provisions).

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.

[67] 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 House Component'.*

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 require extending these analyses.

4.2 Baseline for analysis

As noted in Section 4.1, 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 4.5).

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.

4.2.1 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 4.2 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 4.1.7
— possible non-compliance.

Table 4.2 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 RIS agreed with this approach. 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.

As noted in Sections 4.1.4 and 4.1.7, the RIS assumes full compliance and does not account for current variations in the application of the NCC in different states and territories. In light of this, any 'perceived' undercompliance[68] 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.

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.

[68] 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.

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

ACIL Allen has an in-house Small Scale Renewable Energy model as part of our suite of energy models. This model projects the proportion of *all* residential buildings with solar PV installed, by jurisdiction, using historical solar PV data and Australian Bureau of Statistics (ABS) data on housing dwellings, and compares these with AEMO's projections. The proportion of *all* residential buildings with solar PV installed, by jurisdiction, in 2019 is set out in the first column of Table 4.3. Given the practical difficulties with installing solar PVs on Class 2 dwellings, most of these installations are likely to be on Class 1 dwellings. Given the lack of data about the split in solar PV penetration by building class, the analysis assumes that the current and future penetration of solar PV in Class 2 dwellings is effectively zero.

C4NET analysis provided by the ABCB indicates that the proportion of *new* dwellings with solar PV in Victoria was 13 per cent in 2019. To estimate solar PV penetration in new dwellings in the other jurisdictions in 2019, the ratio of the proportion of new homes with solar PV to the proportion of all buildings with solar PV in Victoria was applied to each of the other jurisdictions, except New South Wales. The NSW Government provided more detailed actual data from BASIX on the proportion of new buildings with solar PV by climate zone in NSW, which was used instead. The proportion of new residential buildings with solar PV installed, by jurisdiction, in 2019 is set out in the first column of Table 4.3 and the projected change in these installations over the period 2019-2031 is shown in Figure 4.1.

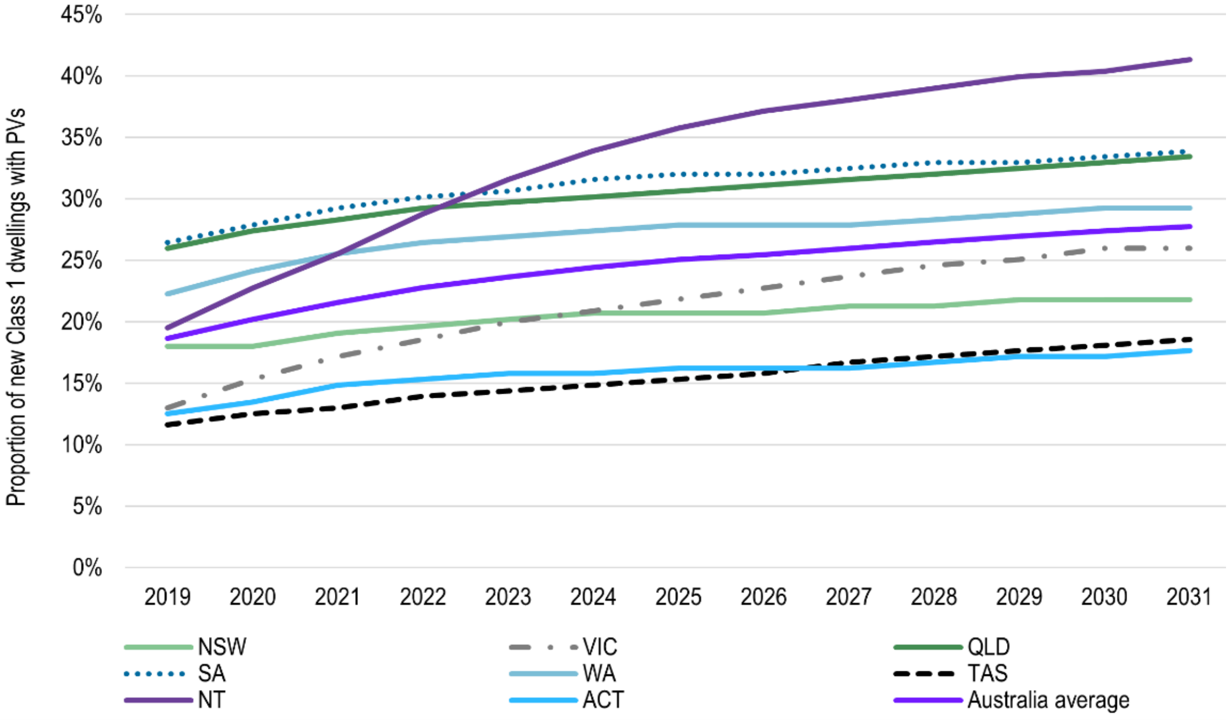
It is assumed that the proportion of dwellings with solar PV installation is the same across different climate zones in each jurisdiction (except for NSW where the solar PV penetration by climate zone was provided).

Table 4.3 Proportion of residential buildings with solar PV, 2019

Jurisdiction	All buildings	New buildings [a]
New South Wales	30%	18%
Victoria	28%	13%
Queensland	56%	26%
South Australia	57%	26%
Western Australia	48%	22%
Tasmania	25%	12%
Northern Territory	42%	20%
Australian Capital Territory	27%	13%
National average	39%	

[a] Refers to Class 1 buildings only.
Source: ACIL Allen.

Figure 4.1 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

The C4NET analysis shows that the average solar PV system size being installed in new dwellings in Victoria in 2020 is around 5.7 kW. Based on this, it was agreed with the ABCB that the modelling undertaken by EES for the RIS would assume an average system size of 5 kW for all new housing under the BAU.[69] This assumption is 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 a 5 kW system).

4.2.2 New residential building stock

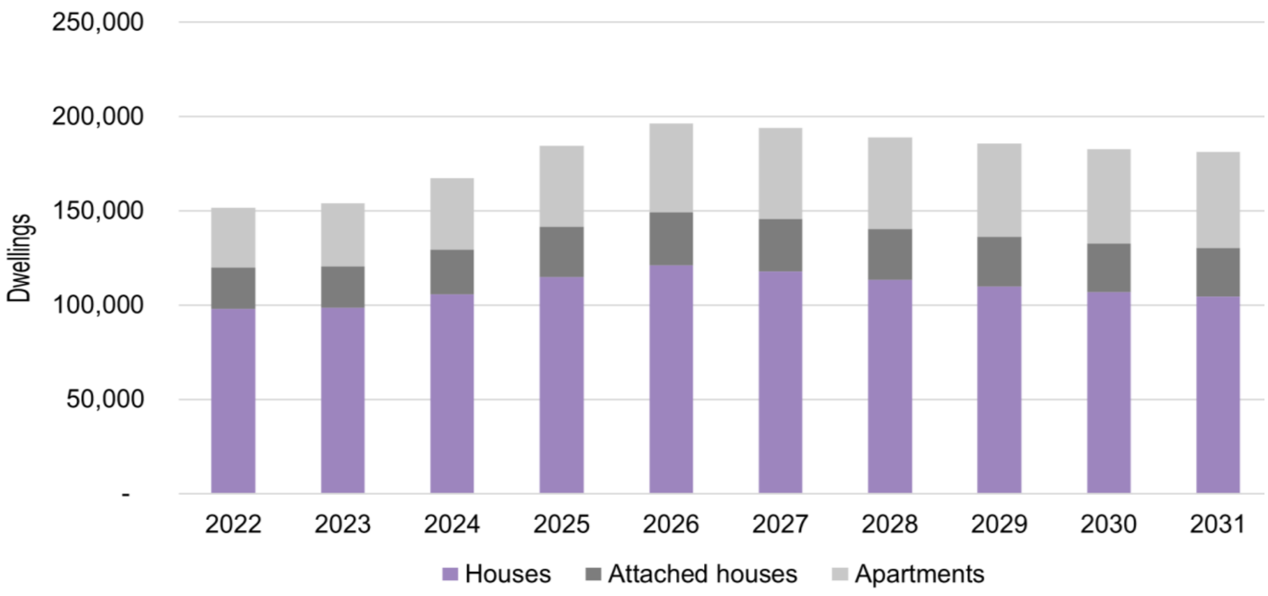
We do not expect that the proposed changes to the NCC will impact on the numbers of new residential buildings constructed. Nevertheless, growth of the residential stock is a key driver for both costs and benefits of the proposed amendments, and distributional issues in the analysis.

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

[69] This is slightly less than the average for Victoria's new housing but takes into account the fact that those installing solar PVs as part of the initial construction are likely to be more financially constrained and hence installer smaller systems.

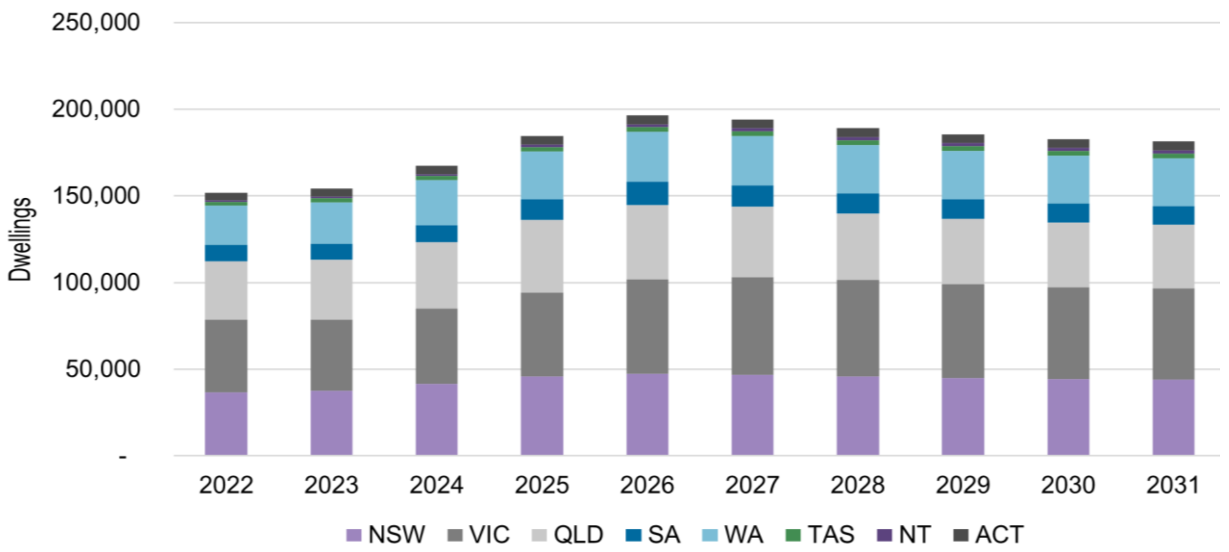
just above 150,000 dwellings in 2022 to around 181,000 dwellings by 2031 (see Figure 4.2 and Figure 4.3**)**.

Figure 4.2 Projected number of new residential dwellings by dwelling type, Australia, 2022 to 2031



Source: ACIL Allen.

Figure 4.3 Projected number of new residential dwellings by state, 2022 to 2031



Source: ACIL Allen

4.2.3 Houses with pools or spas

As mentioned in Section 3.2, 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 and hence are not included in the modelling.

— Estimates about the costs and benefits associated with dwellings with pools under NCC 2022 (this is discussed in more detail in Section 4.3.5).

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 4.4), which supports this assumption.

Table 4.4 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 4.5) 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 4.4 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 4.6. 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 4.5 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 4.6 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 4.4. Totals may not add up due to rounding.
Source: ACIL Allen.

4.3 Impact assessment

4.3.1 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
— 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[70] and Class 2 dwelling in each of the climate zones and jurisdictions outlined in Table 4.7 and Table 4.8.

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 4.7 and Table 4.8. 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.[71] 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

[70] 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 dwellings.

[71] 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.

types. In total, ten heater/cooler combinations were combined with each of the seven water heater types[72]. 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.

More information 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 House Component'.*

Table 4.7 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.

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

Table 4.8 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 representative dwellings modelled by EES were aggregated by allocating the projected number of new dwellings by class by jurisdiction (outlined in Section 4.2.2) 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 4.9 and Table 4.10).

Notably, the cells shaded in Table 4.9and Table 4.10 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
— 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 4.9 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%

NCC Climate Zone	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
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: Source: CSIRO Australian Housing Dataset.

Table 4.10 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: Source: CSIRO Australian Housing Dataset.

4.3.2 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.[73]

— 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.

Given these complexities, refurbishments have been excluded from the CBA.

4.3.3 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[74] 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).

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.[75]

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).

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[73] 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.

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

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

- 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[76] for an increase in energy efficiency from 5 to 6 stars in 2009.
- Given 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, the CBA for the NCC 2022 changes will account for the costs of addressing thermal bridging, but not the benefits.[77]
- 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 treatment of the impacts of thermal bridging in timber frame buildings is an area where the RIS is seeking input from stakeholders during the consultation period.

4.3.4 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.[78] 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.[79] 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.

  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 4.4.3.[80]

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[76] 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

[77] 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.

[78] These characteristics include (amongst other), small area and challenging proportions, poor orientation, and problematic topography.

[79] For additional details of this analysis please refer to AECOM 2020, *Difficult Blocks – Final Report Revision 2,* September.

[80] 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.

- SGS Economics & Planning to estimate the proportion of residential lots that fall within the small and narrow lot categories[81] across Brisbane, Melbourne and Sydney (which make up about ¾ of residential development in Australia).[82] 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 4.11. 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, we included in the CBA the additional compliance costs stemming from the proposed changes in thermal requirements for Class 1 dwellings built on difficult blocks. The proportions of difficult blocks outlined in Table 4.11 are assumed to remain constant over the analysis period.

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 0.

Table 4.11 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.

4.3.5 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

[81] 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.

[82] 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.

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.

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[83] 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 4.3.6).

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.[84]

For the purposes of the RIS, 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.

The RIS will be used to seek more information on this issue. 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.

4.3.6 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

[83] 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 4.3.6

[84] City of Melbourne 2015, *Community Attitudes and Barriers to Rooftop Solar Final report*, August.

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 4.13 and described in more detail in the following sections.

The specific equipment selections and solar PV capacity installed under each of the upgrade pathways described above (and the BAU) are outlined in more detail in EES' report '*NCC 2022 Update - Whole of House 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 4.4.1). To assume otherwise would bring into question the revealed preferences under the status quo and overlook amenity costs.

Class 1 dwellings

Class 1 dwellings built as **6 stars without solar PV** in the BAU and that have good solar access[85] are assumed to upgrade the building fabric to 7 stars and meet the WoH requirements using the lowest cost upgrade pathway of three alternative response options analysed by EES. The three alternative response options analysed by EES are:[86]

— 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) [87]
— 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) [88]

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[85] Note that, as discussed in Section 4.3.5, the RIS assumes that all Class 1 dwellings can install solar PVs (i.e., have good solar access and no overshadowing issues).

[86] For more information about the upgrade responses modelled by EES as inputs into the RIS please refer to EES 2021, *NCC 2022 Update - Whole of House Component*, Draft Report, May.

[87] 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.

[88] Where equipment selection changes, there is a large number of combinations that could be used to meet the NCC 2022 requirements. For his modelling, EES only modelled an option where central conditioning

— altering the equipment selection plus adding as much solar PV as is required to meet the particular regulatory stringency level.

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 three 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 three options modelled by EES. This may mean the addition of more solar PV than assumed under the BAU case (within limits) 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 in 1) 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 in 2) above.

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 three 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[89]).

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 4.3.5, generally results in higher costs than using the lowest cost upgrade pathway of the three alternative response options analysed by EES). While this is the most likely outcome given the practical difficulties with installing solar PVs on Class 2 dwellings (see Box 4.1 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).

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.

[89] Additional details about the equipment in the pool scenario modelled can be found in EES's WoH report.

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 in 6) above.

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 4.12, these dwellings represent a significant proportion of dwellings in some states (e.g. NSW, Queensland and WA). The regulatory default requirement for these buildings is that a Minimum Energy Performance Standards (MEPS) level heat pump is assumed to have been installed. This is designed to ensure that heaters/coolers are not simply installed straight after occupancy as a means of avoiding the installation of solar PV during construction. 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 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 4.3.5, 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 high efficiency equipment (including heating and cooling). 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. This assumption *does not mean* that the NCC 2022 would 'force' the installation of heating and cooling in these buildings. 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 combination of a higher performing shell and a high efficiency water heater. However, given the limitations on the extent of the modelling that EES conducted for the RIS, those alternative upgrade pathways were not modelled. 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.

Table 4.12 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%

Source: EES.

Table 4.13 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	Yes, only for steel framed buildings	No

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?**
				adding more solar PV than under the BAU or changes to equipment selections under the BAU)		
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) 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
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	Yes, only for steel framed buildings	No – these costs are for dwellings being improved

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?
				adding more solar PV than under the BAU or changes to equipment selections under the BAU)		from 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

Box 4.1 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 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.

  – If there is not space in existing electrical risers, then there could be a need for extra-long cable runs and impose costs to drill core holes through the floors. Larger capacity inverters may be able to be used, thereby lowering the total inverter cost per installed kW.

— 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 limiting the available space for solar PV installations.

Given the above, and as it is not feasible 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).

4.4 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.

4.4.1 Change in construction costs

Construction costs 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. More information on these costs is provided in EES's and TIC's reports, *NCC 2022 Update - Whole of House Component* (May 2021) and *Cost and Benefits of upgrading building fabric from 6 to 7 stars* (September 2020).

It is assumed that the resource cost of these changes in construction is equal to 90 per cent of the construction costs estimated by EES and TIC.[90] 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.

The difference in construction costs between NCC 2019 and NCC 2022 compliant dwellings is then used in this analysis as the basis for estimating the compliance costs associated with the proposed changes in the energy efficiency provisions.

The estimated changes in construction costs for Class 1 and Class 2 buildings under the different upgrade pathways described in Section 4.3.6 are outlined in the next chapter.

Assumed reductions in window sizes

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 assumes an average reduction in window size.[91]

Notably, CSIRO's dashboard data 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

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[90] 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.

[91] 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*'.

7 star dwellings is lower than in 6 star dwellings. On average across Australia, 7 star dwellings have 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 state they assume that 60 per cent of the window area reduction observed in CSIRO's data is implemented to meet the new thermal requirements.

TIC's analysis does not take into account of the effects on amenity or dwelling value.

While it is recognised that a reduction in window size may have a cost in terms of loss of amenity and potentially dwelling value, these costs have not been quantified and is an area where the RIS is seeking stakeholder feedback.

4.4.2 Appliance 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 appliances need to be of sufficient capacity to ensure that comfortable temperatures can be maintained within the dwelling under most climatic conditions.[92] As thermal performance improves, the dependence on these appliances to provide comfort decreases and smaller appliances 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 appliances being installed as a result of moving from 6 to 7 stars) were estimated by EES for the NCC 2022 RIS process. The average appliance cost savings per dwelling as estimated by EES for each jurisdiction are outlined in Table 4.14.

These appliance 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).

Table 4.14 Average appliance cost savings per dwelling by jurisdiction

Jurisdiction	Class 1 ($ per dwelling)	Class 2 ($ per SOU)
NSW	$145	$112
QLD	$142	$83
VIC	$225	$139
SA	$232	$125

[92] ABCB 2006, *Regulation Impact Statement: Proposal to amend the Building Code of Australia to increase the energy efficiency requirements for houses*, March.

Jurisdiction	Class 1 ($ per dwelling)	Class 2 ($ per SOU)
WA	$166	$92
TAS	$211	$118
NT	$141	$103
ACT	$236	$135

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 appliance 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 appliance. However, delivering this cost saving would require the industry's appliance sizing practices to reflect the dwelling's energy efficiency. While the Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH) has produced some useful appliance sizing applications, these are not in general use. Until industry appliance sizing practices change (and more accurate appliance sizing guidelines using NatHERS outputs are developed), this will remain a potential benefit rather than an immediately deliverable benefit.
— Heating and cooling appliances only come in incremental sizes. If appliance size increments are too broad, then even allowing for the reduced building load due to improved thermal fabric and higher requirement for appliance efficiency, the next smaller appliance may be too small.

4.4.3 Difficult blocks costs

Section 4.3.4 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 4.15. [93] 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 4.15 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

[93] 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
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
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.

4.4.4 Thermal bridging costs

As noted in Section 4.3.3, 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[94], have been estimated by TIC[95] and are presented in Table 4.16 and Table 4.17.

[94] As noted in Section 4.3.3, 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.

[95] 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 4.16 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 House Component, Draft Report, May.

Table 4.17 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 House 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 4.18 and Table 4.19.

Table 4.18 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 4.19 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.

4.4.5 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, appliances 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.[96]
- 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).[97]
- 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, eg, the electricity and gas network sector. [98]
- 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.[99] 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. [100]

[96] Moreland Energy Foundation 2017, *Changes Associated with Efficient Dwellings Project – Final Report*, prepared for the Department of the Environment and Energy.

[97] 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.

[98] HoustonKemp 2017, Residential Buildings Regulatory Impact Statement Methodology, report for the Department of the Environment and Energy, April, p.22.

[99] 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.

[100] 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.

- 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".[101]
- 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).[102]
- The 2018 Decision RIS for energy efficiency of commercial buildings in the NCC 2019[103] 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:

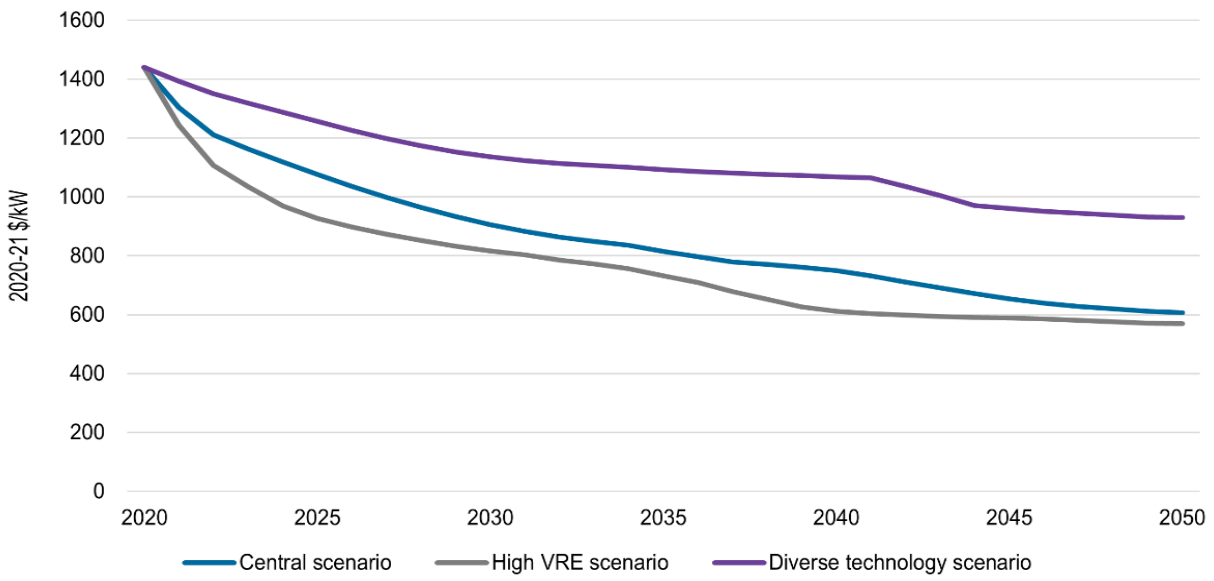
  Where cheaper and more energy efficient technologies (and there are no compromises on other characteristics) becomes available (such as LED lighting), they are likely to be adopted by industry even without the need for regulatory change.
- Each year CSIRO and the Australian Energy Market Operator (AEMO) 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 2020-21 report shows a clear trend of decreasing capital costs for solar systems across the three scenarios modelled (see Figure 4.4) that extends for at least two decades.

[101] 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*.

[102] 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.

[103] 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 4.4 Projected capital costs for rooftop solar PV by scenario



Note: The Central scenario refers to current stated global climate polices (as of late 2020), with the most likely assumptions for all other factors such as renewable resource constraints. The High VRE scenario refers to a world that is driving towards net zero emissions by 2050 and where technical, social and political support for variable renewable electricity generation is high. The Diverse Technology 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 is reached by 2070.

Source: Graham, P., Hayward, J., Foster J. and Havas, L, 2021, GenCost 2020-21: Final report, Australia, June.

Given the above evidence, for the central case analysis in this RIS we have:

— included the CSIRO's projected reductions in costs (learning rates) of rooftop solar PV
— not included learning rates for any other upgrade costs. The assumption of zero learning effects for these other costs results in conservative estimates of cost impacts.

The effect of further decreases in overall upgrade costs (including solar PV) was tested via sensitivity analysis.

4.5 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 8.1.

4.5.1 Changes in dwelling energy consumption

Energy flows for dwellings under the BAU and the different upgrade pathways outlined in Section 4.3.6 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 House 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 4.3.6 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[104], '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[105], 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.

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[106] 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.[107]
— 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.[108]
— 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

[104] Ibid, p. 73.

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

[106] 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.

[107] 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.

[108] Carbon Trust 2011, *Closing the gap: Lessons learned on realizing the potential of low carbon buildings. Carbon Trust*, London.

effect, tends to occur for low-energy dwellings, where occupants consume more than the rating.[109]

— 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.[110]
— 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.[111]
— 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.[112]
— 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.[113]

  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 6.4.1 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): [114]

> 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

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[109] 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.

[110] 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.

[111] 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.

[112] 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.

[113] 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.

[114] 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.

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.

— Modelling done by Tony Isaacs and Robert Foster for a 2011 Mandatory Disclosure RIS[115] included a 30 per cent rebound effect (that is, it included a 30 per cent discount to energy savings).
— McKinsey (2009) refers to a rebound effect of 15 to 30 per cent.[116]
— A report by the International Energy Agency (IEA) on the multiple effects of energy efficiency notes that:[117]

  Direct rebound effects can range from 0% (e.g. in whiteware) to as much as 65% (e.g. electrically heated homes in California) (Hertwich, 2005). However, estimates tend to converge between 10% and 30%.

  This IEA report also refers to a total macroeconomic rebound effect in the range of 10 per cent to 30 per cent in the UK and suggests the rate is similar in other developed countries and higher in developing countries.

— O'Leary (2016)[118] suggests than the rebound effect for efficiency alone should be nearer the low end of estimates or around 5 per cent to 10 per cent to expected energy savings.

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 in the IEA and

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115 Allen Consulting Group (ACG) 2011, *Mandatory Disclosure of Residential Building Energy, Greenhouse and Water Performance: Consultation Regulation Impact Statement*, report to the National Framework for Energy Efficiency Building Implementation Committee, March.

116 McKinsey & Company 2009, *Unlocking Energy Efficiency in the U.S*. Economy, https://www.sallan.org/pdf-docs/MCKINSEY_US_energy_efficiency.pdf, accessed 27 July 2020.

117 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.

118 O'Leary, Timothy 2016, *Industry adaption to NatHERS 6 star energy regulations and energy performance disclosure models for housing*, December, https://minerva-access.unimelb.edu.au/bitstream/handle/11343/220478/Tim%20Oleary%20final%20with%20corrections.pdf?sequence=1&isAllowed=y, accessed 2 March 2021.

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[119]. As noted by IEA: [120]

> 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.

The existence and magnitude of these other 'rebound' benefits in the context of new housing in Australia has not been explored in a level of detail that would allow its incorporation in the impact analysis, however, our approach to effectively value the rebound effects as zero results in more conservative estimates of the potential impact of the policy.

4.5.2 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

[119] Notably, as discussed in Section 3.1, 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).

[120] 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.

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 7.

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 4.10) , 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.

4.5.3 Energy prices

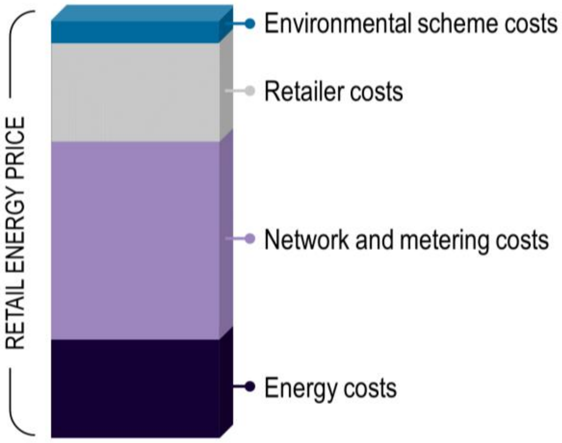
Electricity and gas

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.

In calculating the value of energy savings, it is critical to not confuse benefits with distributional impacts. For example, the 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 that are redistributed to other customers. For example, total network costs would only be reduced if network augmentation can be deferred or avoided. 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 costs are 'fixed'.

The retail energy price broadly comprises four components as illustrated in Figure 4.5.

Figure 4.5 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 existing residential building stock.

In the long run, investment in new generation capacity may be deferred or avoided. However, new generation capacity is currently driven by a range of policy initiatives that are incentivising additional new energy supply and reductions in the demand for energy from centralised generation. The impact of increases in energy efficiency requirements in the NCC 2022 on the capacity of generation in the wholesale electricity market is not material relative to these policy initiatives.[121]

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)

[121] As an example, the minimum objectives of the *Electricity Infrastructure Investment Act 2020 (NSW)* are to construct 12 GigaWatts (GW) of large-scale renewable energy capacity and 2 GW of long-duration storage infrastructure in NSW by 31 December 2029.

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 scheme costs 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 network costs. 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 network costs (discussed in more detail in Section 4.5.4).

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.[122]

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.

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

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

> accurate approach is to estimate the resource cost savings from reduced electricity and gas consumption, ie, reduction in network and wholesale costs.[123]

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. [124]

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,[125] although retail prices continue to be used to assess the impact at a household level, as discussed in the next section.

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 B and our projections of wholesale electricity and gas prices are shown in Figure 4.6 and Figure 4.7.[126] 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.

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.

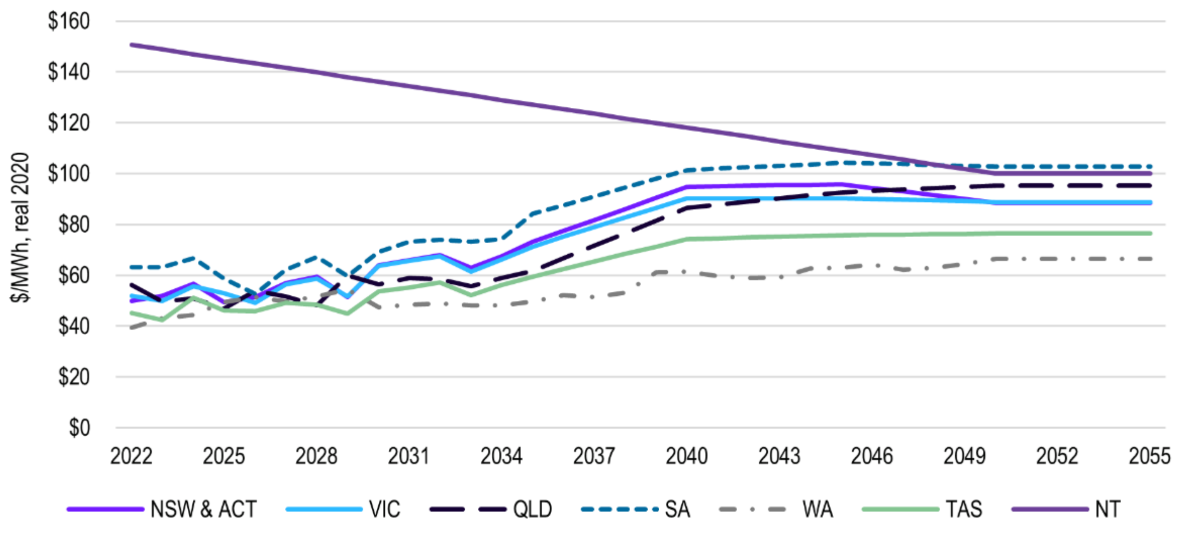
[123] Houston Kemp, *Residential Buildings Regulatory Impact Statement Methodology,* 6 April 2017, page 14.

[124] Ibid, page 15.

[125] Prior to the release of the Houston Kemp report, the avoided wholesale and network cost approach was used for some analyses but not all.

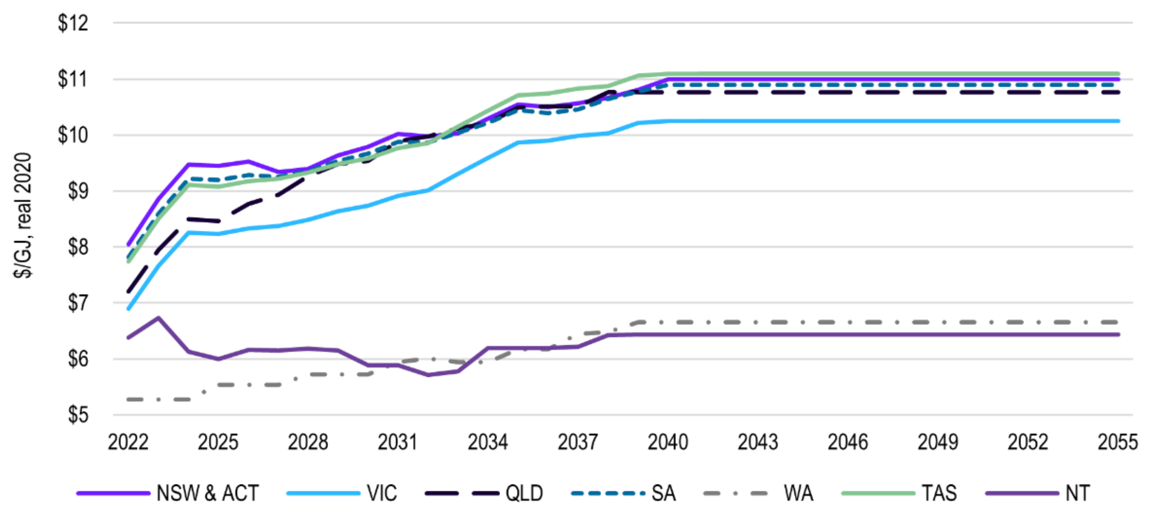
[126] We undertook wholesale electricity market modelling in the National Electricity Market to assess the impacts of the proposed NCC 2022 on the energy market, as discussed in section 6.5. The projected wholesale electricity prices from that modelling for the jurisdictions in the National Electricity Market were used for this RIS. The projected wholesale electricity prices for Western Australia and the projected wholesale gas prices were based on previous modelling undertaken by ACIL Allen.

Figure 4.6 Wholesale electricity price projections, $ per MWh



Source: ACIL Allen.

Figure 4.7 Wholesale gas price projections, $ per GJ



Source: ACIL Allen.

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 Australia-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 4.8 to Figure 4.10. 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[127] 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
  - for WA, we used the average of peak and off peak retail prices from the EES's Whole of House Report for the NCC 2022[128].
  - for NT, we assumed the retail electricity price remained constant in real terms as it is set by the Government at below cost
- for retail gas prices we used the prices in EES's Whole of House Report for the NCC 2022[129] for the start year and projected the change in these prices over time using information sourced from our proprietary model *GasMark*
- feed in tariffs to value exports to the grid were estimated/projected using the average of the annual large-scale solar dispatch weighted wholesale electricity price in each jurisdiction plus 6 per cent, which represents loss factors that the retailer will pass onto the end consumer.

Retail firewood prices for the CBA have been assumed to be the same as in EES's modelling – $1.56 cents per megajoule (MJ)[130]. 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 EES.[131] 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 4.20.

[127] AEMC*, Residential Electricity Price Trends 2020, Final report*, 21 December 2020.

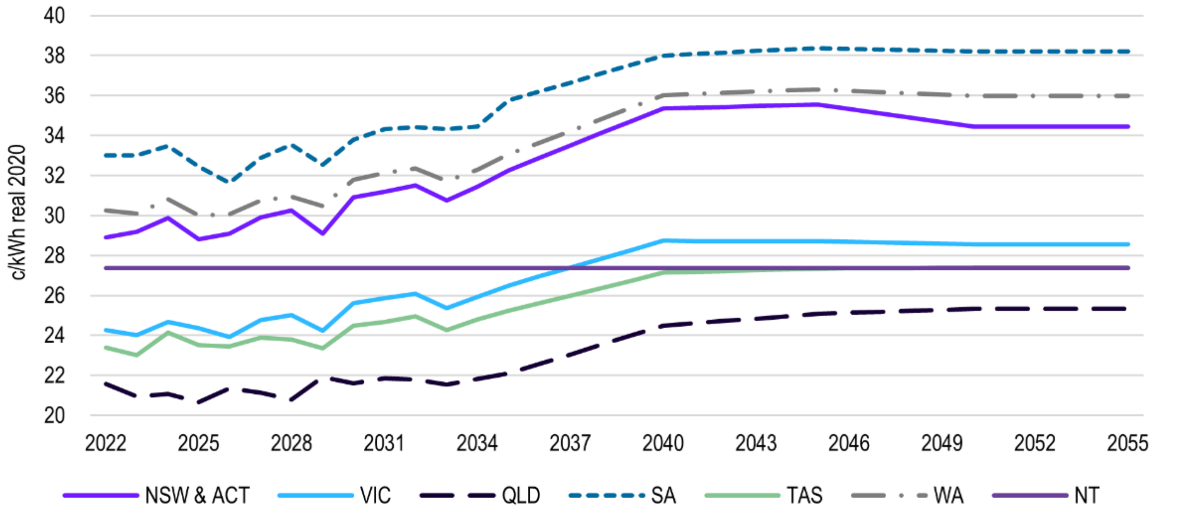
[128] EES 2021, *NCC 2022 Update - Whole of House Component, Draft Report*, May.

[129] Ibid.

[130] Both for the CBA and distributional analysis.

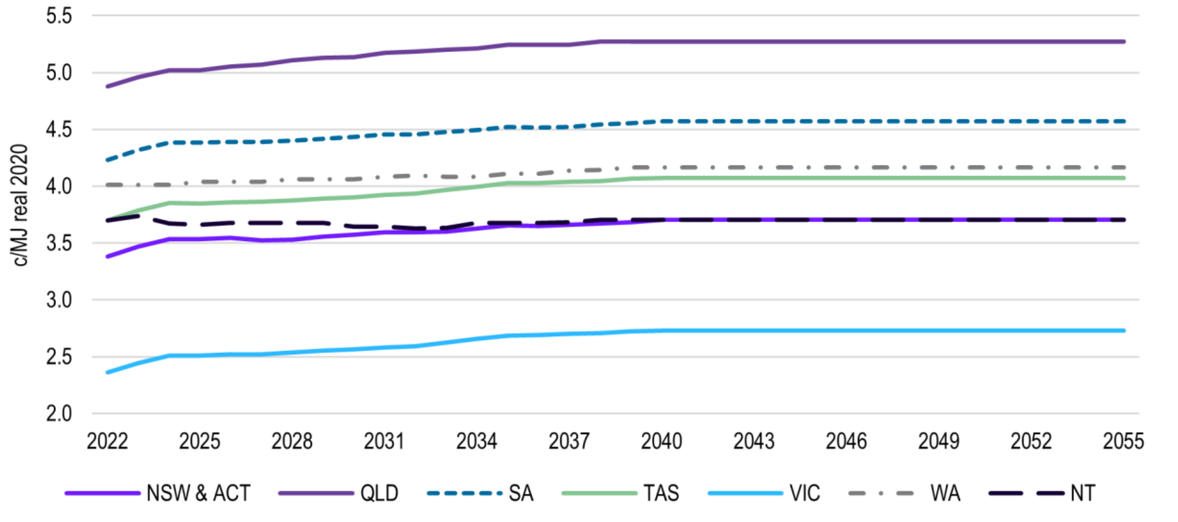
[131] EES 2021, *Residential Energy Disclosure Model*.

Figure 4.8 Retail electricity prices, cents per kWh



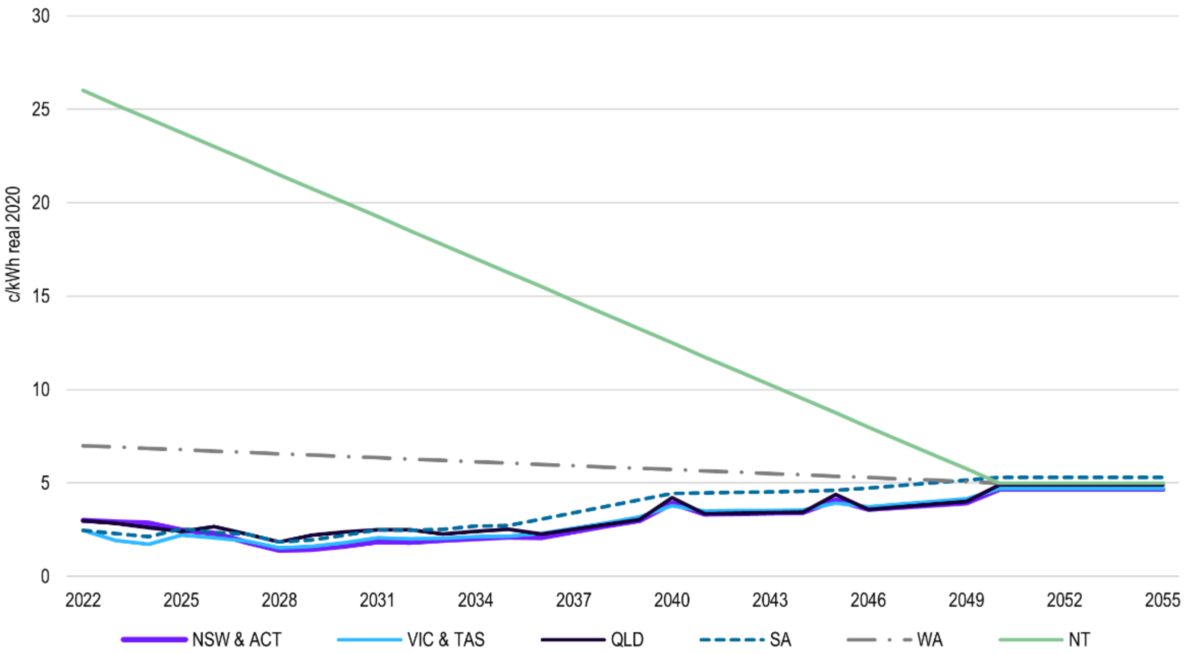
Source: ACIL Allen.

Figure 4.9 Retail gas prices, cents per MJ



Source: ACIL Allen.

Figure 4.10 Feed in tariff for PV exports to grid, cents per kWh



Source: ACIL Allen.

Table 4.20 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
TAS	3.98	5.30
NT	3.60	4.80
ACT	4.13	5.50

[a] this is a reference note

Note: Prices are assumed to remain constant in real terms over the analysis period.

Source: ACIL Allen based on EES data.

4.5.4 Deferred electricity network costs

As discussed in Section 4.5.3, 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[132] by:

1. imputing a reduction in peak demand based on the reduction in energy use by using a conservation load factor (CLF)[133]
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.

Imputing a reduction in peak demand

The most recent RIS for energy efficiency in residential buildings 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 4.21, 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 have applied a CLF of 0.50.

Table 4.21 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

[132] See Strategy. Policy. Research 2018, pp38-39 and Jacobs 2019 pp33-34.

[133] 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.

Residential end-use	Basis / Source	Conservation load factor	
Residential pool/spas	Household occupancy, Ergon Energy profile	0.73	0.84

Source: Jacobs, 2019 Victorian Energy Upgrades Program, Energy Market Modelling, Final Report, 17 October 2019, p.37

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.[134]

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.[135]

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.

[134] Jacobs, *2019 Victorian Energy Upgrades Program, Energy Market Modelling, Final Report*, 17 October 2019, p.33

[135] 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.

4.5.5 Deferred gas pipeline costs

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.

4.5.6 Reduced greenhouse gas emissions

The avoided greenhouse gas (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[136] in each jurisdiction.

The Department of Industry, Science, Energy and Resources (DISER) reports emissions factors for end users of electricity in each state and territory, including:

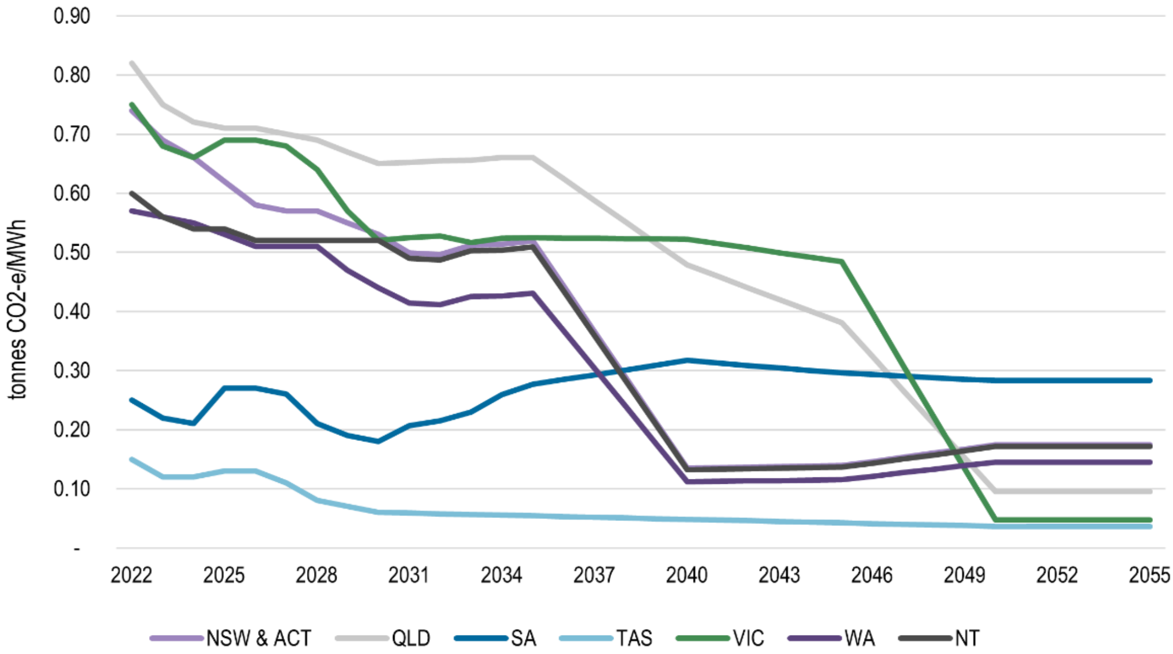
— Scope 2 emissions — these are indirect emissions from the generation of the electricity purchased and consumed
— Scope 3 emissions — these are indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution network.

[136] The combination of energy sources used within the electricity market.

In late 2020 DISER released both their latest estimate of emissions factors (which refers to 2017-18[137]) and their emissions projections (from 2020 to 2030) providing an indicative assessment of how Australia is tracking against its emissions reduction targets.[138]

To estimate the GHG emissions reductions for the proposed changes in NCC 2022 we used DISER's projections 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 (see Figure 4.11).

Figure 4.11 Electricity emissions factors over time, tonnes CO2-e/MWh



Source: ACIL Allen and DISER 2020, Australia's emissions projections, December.

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 4.22 provides details of the emissions factors used.

[137] DISER 2020, *National Greenhouse Accounts Factors, Australian National Greenhouse Accounts*, October, https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2020, accessed 2 March 2021.

[138] DISER 2020, *Australia's emissions projections*, December, https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2020, accessed 2 March 2021.

Table 4.22 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 greenhouse gas 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)[139]. This has been assumed to remain constant over time.

LPG

For LPG, we assumed a greenhouse gas 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.[140] This has been assumed to remain constant over time.

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 have been 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

[139] EES 2021, *Residential Energy Disclosure (RED) Model*, prepared for ACIL Allen.

[140] Ibid.

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 greenhouse gas 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[141], 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[142] 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.

For the central case analysis in this RIS, we have used the second approach, and DISER instructed us to use an ACCU (or equivalent unit) price series to value the avoided GHG emissions.

The ACCU spot price as at December 2020 was $16.55 per tonne.[143] As forward prices for ACCUs are not available, we have projected the change in this price over time using information sourced from our proprietary model *PowerMark*. Using this approach, we estimate that the price per tonne of abatement would reach $25 in 2030 and around $45 in 2050 (see Figure 4.12).

Additional sensitivity analysis was conducted to test the effects of changes to the value of avoided GHG emissions.

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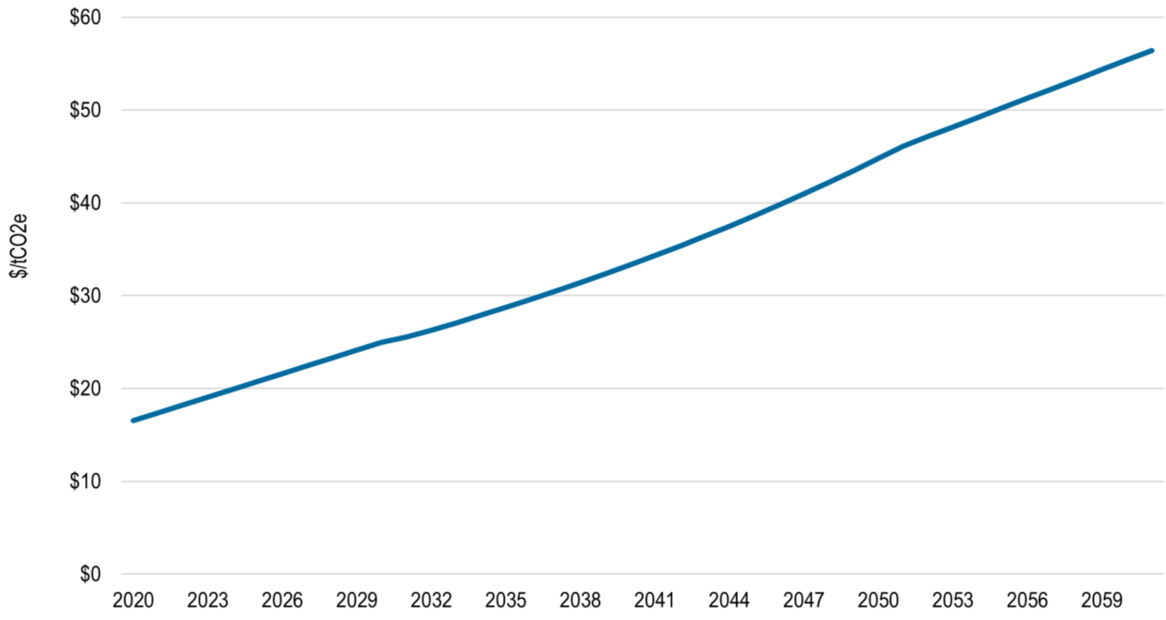
141 An ACCU is a unit issued to a person by the Clean Energy Regulator. Each ACCU issued represents one tonne of carbon dioxide equivalent (tCO2-e) stored or avoided by a project.

142 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.

143 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.

Figure 4.12 Cost of carbon estimates, $/tCO2e



Source: ACIL Allen estimates based on CER 2021, Quarterly Carbon Market Report December Quarter 2020, March.

4.5.7 Health 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 of implementing energy efficiency and clean energy measures produced by Scorgie et al. (2019) for the NSW Government.[144] In this report, the authors estimated health damage costs of coal-powered electricity generation of AUD$2.40 per MWh of total energy generation.[145]

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

[144] Scorgie Y, Mazaheri M, Chang L, Ryan L, Fuchs D, Duc H, Monk K and Trieu T 2019, *Air Quality and Public Health Co-benefits of Implementing Energy Efficiency and Clean Energy Measures in New South Wales*, Final Report, report prepared by the NSW Office of Environment and Heritage, February.

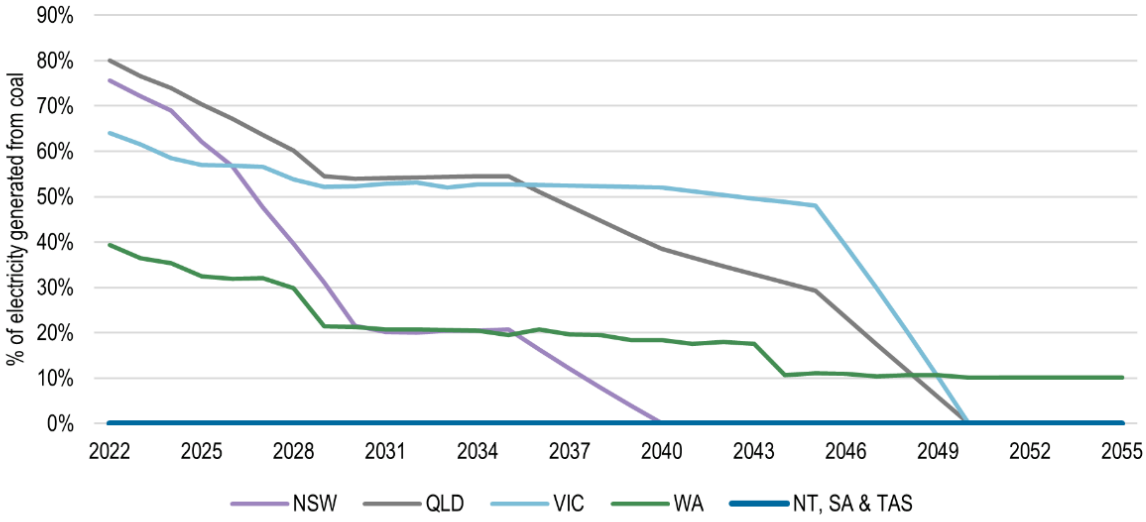
[145] This estimate represents the health cost reductions per MWh reduction in total energy generation due to energy demand reduction and are based on the life years gained approach for the medium demand shock scenario and the 2026–2118 period (excluding ramp up), and assuming a 7 per cent discount rate. This is the same estimate used by the NSW Government in other cost benefit analyses of energy efficiency policies.

$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 4.13[146]) 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 4.13 Percentage of electricity generated from coal



Source: ACIL Allen

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[147] 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 and reductions in natural gas use.[148] 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

[146] It is assumed that the percentage of electricity generated in most states after 2050 is zero.

[147] 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.

[148] 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.

proposed changes to the NCC (sourced from our proprietary model *PowerMark* and derived for Option B as described above) and the gas savings calculated previously.

4.6 Questions for stakeholders

10. Are there any assumptions or parameters used in the analysis that should be different? If so, is there alternative evidence that could be considered?
11. Should thermal bridging in timber-framed buildings be incorporated in the analysis? If so, how?
12. Is it reasonable to assume that industry's response to the proposed changes will be to select the lowest cost alternatives (e.g. installing PV, adopting high efficiency appliances or a combination of approaches) in every case?
13. How would industry most likely respond to the proposed whole-of-house changes under each of the proposed options?
14. How would industry most likely respond to the proposed thermal fabric changes under each of the proposed options?
15. In some cases, smaller windows are assumed to be used to constrain costs or achieve compliance with the proposal. Should the impact on occupant amenity be valued and how?
16. Does the use of a high efficiency equipment solution as a proxy for other non-modelled solutions over/under-estimate the costs of the proposed changes for Class 2 dwellings? If so, by how much?
17. Does the above proxy over/under-estimate the benefits for Class 2 dwellings? If so, by how much?
18. Is it practical to apply the WoH proposal to refurbishments?
19. How will the proposals be applied to refurbishments in practice?
20. Would the cost of applying the WoH proposal to renovations be broadly similar to the cost incurred in new dwellings?
21. Would the benefits resulting from applying the WoH proposal to renovations be broadly similar to the benefits received by new dwellings?
22. Are the assumptions used to estimate current and future penetration of solar PV in new buildings under the BAU appropriate and is there other evidence that could be considered?
23. Do you have any information that could be used to estimate the proportion of blocks for which solar PV could not be installed, i.e. those that are shaded and where solar PV could not be installed for Class 1 dwellings?
24. Do you have any information that could be used to estimate the proportion of Class 2 apartments for which sufficient solar PV could be installed to meet the energy use budget of each individual apartment?
25. As noted in this chapter, expected decreases in feed-in tariffs would effectively increase the stringency of the proposed WoH requirements under Option A over time. Do you have any views on this issue?

Individual dwelling impacts 5

This chapter summarises the impacts of the proposed changes to the NCC on individual sample dwellings from a societal perspective (i.e. measured using wholesale energy prices as a proxy for avoided resource costs).

As noted in Chapter 4, 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.

5.1 Individual 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 4.3.6, for each of the climate zones and jurisdictions modelled by EES (details of these are provided in Appendix C)

— 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 5.1 to

— **Table 5.4**.

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 economy-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 4, are only incurred by dwellings that are rated 6 stars in the BAU

— the estimated costs of mitigating thermal bridging in steel frame buildings.

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 $7,273 (mainly driven by the costs of solar PV panels), while the estimated additional costs for a Class 1 dwelling in CZ 5 in Western Australia are marginal, at only $898. Under Option B, the highest estimated cost increase in Class 1 dwellings would be experienced in CZ7 in NSW (at $2,871), and the lowest estimated cost increase would be experienced by dwellings in CZ1 in Western Australia.

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 $2,024 for a unit in the ACT under Option A, and $179 for a unit in CZ1 in Queensland 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 except apartments in CZ5 in South Australia, the additional estimated costs of complying with Option B are lower than the costs of complying with Option A. For an apartment in CZ5 in South Australia, the cost of complying with Option B is estimated to be marginally higher than the cost of complying with Option A.

Table 5.1 Estimated marginal construction costs for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option A, $/dwelling ($2021)

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	862	345	-157	590	-128	1,512
NSW	4	1,554	709	-183	860	-133	2,806
NSW	5	1,549	735	-187	905	-134	2,868
NSW	6	1,410	1,098	-192	976	-135	3,156
NSW	7	1,787	927	-195	838	-127	3,230
NSW	8	1,396	4,531	-229	63	-146	5,614
VIC	4	1,552	2,089	-199	6	-213	3,236
VIC	6	1,405	2,375	-204	6	-218	3,364
VIC	7	1,949	2,375	-205	6	-219	3,907
VIC	8	1,300	4,098	-212	7	-226	4,968
QLD	1	552	475	-78	734	-95	1,588
QLD	2	846	107	-99	183	-111	926
QLD	3	826	475	-106	734	-125	1,804
QLD	5	1,508	490	-106	223	-125	1,990
SA	4	1,595	287	-384	416	-224	1,691
SA	5	1,144	287	-378	416	-218	1,250
SA	6	1,439	730	-388	416	-229	1,969
WA	1	406	622	-313	307	-84	937
WA	3	755	621	-362	307	-139	1,181
WA	4	1,367	138	-350	336	-135	1,357

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
WA	5	935	138	-362	336	-149	898
WA	6	1,340	502	-359	338	-150	1,670
TAS	7	1,565	325	97	993	-177	2,804
NT	1	1,378	6,086	-80	0	-111	7,273
NT	3	1,360	2,019	-99	0	-132	3,149
ACT	7	1,290	202	-115	643	-158	1,863

[a] Includes the cost of solar PV panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

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 4. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 5.2 Estimated marginal construction costs for Class 1 composite dwellings across different jurisdictions and climate zones modelled under Option B, $/dwelling ($2021)

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	862	326	-157	584	-128	1,486
NSW	4	1,554	474	-184	851	-133	2,562
NSW	5	1,549	499	-188	895	-134	2,622
NSW	6	1,410	565	-194	965	-135	2,610
NSW	7	1,787	514	-180	877	-127	2,871
NSW	8	1,396	678	-212	1,125	-146	2,840
VIC	4	1,552	53	-175	441	-213	1,658
VIC	6	1,405	77	-173	445	-218	1,535
VIC	7	1,949	53	-174	445	-219	2,055
VIC	8	1,300	628	-175	445	-226	1,972
QLD	1	552	10	-85	19	-95	401
QLD	2	846	10	-100	20	-111	666
QLD	3	826	10	-112	19	-125	618
QLD	5	1,508	11	-113	20	-125	1,301
SA	4	1,595	54	-410	322	-224	1,338
SA	5	1,144	53	-398	307	-218	887
SA	6	1,439	83	-408	328	-229	1,212

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
WA	1	406	109	**-307**	245	**-84**	368
WA	3	755	109	**-356**	245	**-139**	614
WA	4	1,367	128	**-350**	335	**-135**	1,345
WA	5	935	124	**-362**	335	**-149**	882
WA	6	1,336	158	**-364**	335	**-150**	1,314
TAS	7	1,565	244	**-44**	275	**-177**	1,863
NT	1	1,378	1,251	**-80**	132	**-111**	2,570
NT	3	1,360	22	**-98**	132	**-132**	1,284
ACT	7	1,290	162	**-124**	441	**-158**	1,612

[a] Includes the cost of solar PV panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

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 4. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 5.3 Estimated marginal construction costs for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option A, $/dwelling ($2021)

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	423	291	1,869	**-82**	2,501
NSW	4	205	307	1,869	**-64**	2,318
NSW	5	531	288	1,869	**-85**	2,604
NSW	6	336	298	1,869	**-75**	2,428
NSW	7	873	281	1,869	**-93**	2,930
VIC	6	289	1,848	1,739	**-80**	3,795
VIC	7	560	1,845	1,742	**-74**	4,073
QLD	1	140	1,385	1,725	**-42**	3,208
QLD	2	413	1,370	1,725	**-59**	3,449
QLD	5	562	1,364	1,725	**-66**	3,585
SA	5	472	124	1,842	**-81**	2,355
WA	5	266	631	1,849	**-45**	2,701
TAS	7	184	**-21**	1,925	**-51**	2,037
NT	1	140	2,740	1,193	**-33**	4,040
ACT	7	329	**-6**	1,743	**-41**	2,024

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total

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 4. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

Table 5.4 Estimated marginal construction costs for Class 2 composite dwellings across different jurisdictions and climate zones modelled under Option B, $/dwelling ($2021)

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	423	241	1,613	-73	2,204
NSW	4	205	257	1,613	-57	2,019
NSW	5	531	238	1,613	-76	2,307
NSW	6	336	247	1,613	-68	2,129
NSW	7	873	231	1,613	-84	2,634
VIC	6	289	2	1,743	-72	1,963
VIC	7	560	8	1,743	-66	2,245
QLD	1	140	13	64	-38	179
QLD	2	413	-2	65	-53	422
QLD	5	562	-9	65	-59	559
SA	5	472	124	1,842	-73	2,363
WA	5	266	616	1,842	-41	2,683
TAS	7	184	-32	1,522	-46	1,628
NT	1	140	285	1,561	-30	1,956
ACT	7	329	-15	1,446	-37	1,724

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 4. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

5.2 Individual 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.[149]

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 4, 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 4.3.6 for each of the climate zones and jurisdictions modelled by EES (details of these are provided in Appendix D). 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 5.5 to Table 5.8.

As shown in these tables, the proposed policy settings are estimated to result in:

— a switch from gas to electricity for some Class 1 and Class 2 dwellings both under Option A and Option B, which results in increased electricity consumption and decreased gas consumption
— overall reductions in the use of LPG and firewood in Class 1 dwellings both under Option A and Option B
— generally, larger reductions in energy consumed in Class 2 dwellings than in Class 1 dwellings in the same jurisdictions/climate zone under both options
— larger reductions in total energy consumption for most Class 1 dwellings (except dwellings in NSW CZ8) and all Class 2 dwellings under Option A, than under Option B.

As discussed in Chapter 4, 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 5.9 to Table 5.12. These

[149] These are captured in the individual dwelling costs outlined in the previous section as cost offsets.

values have been calculated using the data in Table 5.5 to Table 5.8 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 $109 (in CZ 2 in Queensland) and $3,018 (in CZ 1 in the Northern Territory) under Option A
  - between $32 (in CZ 2 in Queensland) and $1,221 (in CZ 1 in the Northern Territory) under Option B
- lifetime benefits for Class 2 dwellings of:
  - between $178 (in CZ 5 in Western Australia) and $1,295 (in CZ 1 in the Northern Territory) under Option A
  - between $25 (in CZ 2 in Queensland) and $706 (in CZ 1 in the Northern Territory) under Option B.

Table 5.5 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	292	-3,541	-10	-3,259	1,000	-116	-42,987	-311	-43,414	20,004
NSW	4	-136	-5,701	-97	-5,934	1,783	-16,737	-71,889	-2,913	-91,539	35,660
NSW	5	217	-5,883	-55	-5,722	1,567	-7,256	-73,131	-1,657	-82,044	31,333
NSW	6	-96	-6,914	-229	-7,239	2,079	-16,660	-90,625	-6,862	-114,147	41,573
NSW	7	-390	-6,110	-106	-6,606	2,069	-22,692	-80,373	-3,186	-106,250	41,375
NSW	8	-5,244	-1,720	-229	-7,193	9,577	-118,624	-43,348	-6,867	-168,838	191,546
VIC	4	-3,096	-186	-119	-3,401	4,450	-71,288	-4,817	-3,561	-79,666	89,009
VIC	6	-2,987	-380	-286	-3,653	3,996	-66,216	-10,592	-8,594	-85,402	79,924
VIC	7	-3,704	-346	-255	-4,305	4,368	-86,831	-9,572	-7,645	-104,048	87,370
VIC	8	-4,965	-668	-489	-6,123	7,893	-115,682	-19,075	-14,684	-149,441	157,854
QLD	1	-2,811	-122	-0	-2,933	1,169	-43,309	-1,465	-1	-44,776	23,373
QLD	2	-657	-127	-4	-788	212	-10,287	-1,607	-108	-12,002	4,242
QLD	3	-3,225	-127	-13	-3,365	1,325	-54,366	-1,607	-400	-56,373	26,507
QLD	5	-1,251	-147	-33	-1,430	1,003	-22,451	-2,036	-981	-25,468	20,065
SA	4	-709	-2,639	-300	-3,648	620	-18,844	-43,855	-8,992	-71,690	12,398
SA	5	-619	-2,439	-167	-3,224	562	-16,119	-37,838	-4,998	-58,956	11,230
SA	6	-898	-3,426	-663	-4,987	1,124	-20,823	-66,041	-19,893	-106,757	22,471
WA	1	-1,140	-1,395	-0	-2,535	1,468	-25,584	-16,746	-2	-42,332	29,355
WA	3	-1,539	-1,558	-20	-3,118	1,709	-36,999	-21,581	-607	-59,186	34,177

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	-488	-2,468	-90	-3,046	416	-12,252	-43,773	-2,713	-58,738	8,318
WA	5	-321	-2,230	-55	-2,606	405	-7,241	-38,482	-1,642	-47,365	8,095
WA	6	-631	-3,408	-241	-4,280	1,189	-13,980	-70,431	-7,221	-91,632	23,781
TAS	7	-2,778	-1,713	-2,936	-7,428	523	-35,439	-30,937	-88,095	-154,471	10,458
NT	1	-6,590	0	0	-6,590	7,078	-161,078	0	0	-161,078	141,561
NT	3	-2,911	0	-2	-2,914	2,518	-67,693	0	-65	-67,758	50,355
ACT	7	-1,361	-2,689	-196	-4,245	570	-24,876	-45,488	-5,877	-76,241	11,402

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 4. 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 5.6 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	412	-3,541	-10	-3,138	947	1,302	-42,981	-309	-41,988	18,934
NSW	4	254	-5,701	-97	-5,543	1,318	-9,516	-71,889	-2,898	-84,302	26,354
NSW	5	587	-5,883	-55	-5,351	1,172	-585	-73,131	-1,645	-75,360	23,450
NSW	6	616	-6,914	-217	-6,515	1,198	-3,536	-90,625	-6,501	-100,661	23,963

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	378	-6,481	-210	-6,313	1,312	-7,490	-85,513	-6,303	-99,305	26,244
NSW	8	652	-9,375	-571	-9,295	1,530	-7,877	-135,205	-17,144	-160,227	30,595
VIC	4	-882	-1,993	-158	-3,032	188	-22,541	-28,036	-4,743	-55,321	3,770
VIC	6	-745	-2,357	-392	-3,494	152	-18,673	-37,148	-11,761	-67,582	3,037
VIC	7	-910	-2,412	-388	-3,710	164	-23,122	-37,921	-11,638	-72,682	3,283
VIC	8	-1,598	-3,108	-928	-5,635	1,178	-39,225	-57,079	-27,854	-124,157	23,570
QLD	1	-381	-115	-0	-496	106	-11,764	-1,378	-1	-13,143	2,130
QLD	2	-84	-127	-3	-214	47	-2,908	-1,607	-75	-4,591	935
QLD	3	-722	-120	-9	-851	106	-21,921	-1,518	-256	-23,695	2,123
QLD	5	-234	-147	-13	-394	73	-7,443	-2,036	-377	-9,856	1,461
SA	4	-200	-2,564	-210	-2,973	219	-11,162	-42,949	-6,286	-60,398	4,378
SA	5	-20	-2,401	-117	-2,537	209	-7,090	-37,386	-3,502	-47,978	4,173
SA	6	7	-3,387	-545	-3,925	164	-5,597	-65,571	-16,354	-87,522	3,271
WA	1	-100	-1,418	-0	-1,518	336	-6,410	-17,021	-2	-23,433	6,720
WA	3	-466	-1,578	-20	-2,064	393	-16,995	-21,769	-607	-39,372	7,858
WA	4	-349	-2,468	-89	-2,906	386	-10,754	-43,773	-2,684	-57,211	7,719
WA	5	-175	-2,230	-54	-2,459	365	-5,638	-38,482	-1,614	-45,734	7,304
WA	6	-188	-3,385	-229	-3,802	335	-6,273	-70,017	-6,873	-83,163	6,706
TAS	7	-660	-1,701	-1,834	-4,195	337	-13,874	-30,791	-55,034	-99,699	6,742
NT	1	-2,698	-64	0	-2,762	1,375	-65,826	-762	0	-66,588	27,494

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	
NT	3	-1,450	-76	-2	-1,529	119	-34,186	-911	-69	-35,167	2,384
ACT	7	-652	-2,685	-122	-3,460	431	-16,660	-45,444	-3,669	-65,773	8,611

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 4. 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 5.7 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	890	-7,418	-0	-6,529	10,619	-89,097	-0	-78,479
NSW	4	735	-7,694	-0	-6,959	6,214	-93,400	-3	-87,189
NSW	5	771	-7,570	-0	-6,798	7,213	-91,101	-1	-83,888
NSW	6	998	-8,319	-0	-7,321	10,490	-100,611	-3	-90,123
NSW	7	650	-8,624	-0	-7,974	2,583	-105,539	-7	-102,964
VIC	6	1,397	-9,676	0	-8,279	5,730	-119,626	0	-113,895
VIC	7	787	-10,280	0	-9,494	-11,005	-132,362	0	-143,367
QLD	1	-2,518	-314	0	-2,832	-10,258	-3,768	0	-14,027
QLD	2	-3,564	-317	0	-3,882	-38,744	-3,821	0	-42,565

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
QLD	5	-3,829	-325	0	-4,154	-44,139	-3,945	0	-48,084
SA	5	851	-7,794	0	-6,943	10,209	-98,390	0	-88,181
WA	5	1,665	-8,166	0	-6,500	28,150	-104,399	0	-76,250
TAS	7	-3,791	-2,547	0	-6,338	-49,698	-34,897	0	-84,594
NT	1	-3,262	-211	0	-3,474	-59,511	-2,537	0	-62,049
ACT	7	-1,184	-5,564	0	-6,749	-15,855	-75,313	0	-91,168

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 4. 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 5.8 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	1,515	-7,418	-0	-5,903	10,619	-89,097	-0	-78,479
NSW	4	1,389	-7,694	-0	-6,305	6,214	-93,400	-3	-87,189
NSW	5	1,425	-7,570	-0	-6,145	14,901	-91,100	-1	-76,200
NSW	6	1,682	-8,319	-0	-6,637	18,395	-100,610	-2	-82,217
NSW	7	1,370	-8,623	-0	-7,254	10,618	-105,525	-7	-94,914
VIC	6	1,868	-9,676	0	-7,808	19,827	-119,626	0	-99,799

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
VIC	7	1,670	**-10,274**	0	**-8,604**	15,526	**-132,181**	0	**-116,655**
QLD	1	**-26**	**-309**	0	**-336**	**-2,093**	**-3,715**	0	**-5,808**
QLD	2	29	**-317**	0	**-288**	**-448**	**-3,821**	0	**-4,269**
QLD	5	**-57**	**-325**	0	**-382**	**-3,034**	**-3,945**	0	**-6,980**
SA	5	851	**-7,794**	0	**-6,943**	10,209	**-98,390**	0	**-88,181**
WA	5	1,677	**-8,166**	0	**-6,488**	28,158	**-104,399**	0	**-76,242**
TAS	7	**-2,598**	**-2,547**	0	**-5,145**	**-35,499**	**-34,897**	0	**-70,395**
NT	1	**-2,206**	**-211**	0	**-2,418**	**-20,314**	**-2,533**	0	**-22,847**
ACT	7	**-316**	**-5,548**	0	**-5,865**	**-5,610**	**-74,864**	0	**-80,474**

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 4. 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 5.9 Estimated present value of energy benefits 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	**-12**	286	2	275
NSW	4	124	468	15	607
NSW	5	43	480	9	531
NSW	6	124	578	36	738
NSW	7	179	511	17	707
NSW	8	1,104	204	36	1,344
VIC	4	647	20	19	686
VIC	6	609	43	45	698
VIC	7	781	39	40	860
VIC	8	1,045	77	77	1,200
QLD	1	419	9	0	428
QLD	2	99	10	1	109
QLD	3	508	10	2	520
QLD	5	208	12	5	225
SA	4	185	243	47	476
SA	5	160	217	26	403
SA	6	216	342	104	662
WA	1	184	67	0	251
WA	3	258	80	3	341
WA	4	83	143	14	240
WA	5	51	127	9	187
WA	6	102	214	38	354
TAS	7	335	165	461	961
NT	1	3,018	0	0	3,018
NT	3	1,294	0	0	1,295
ACT	7	239	254	31	524

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 4. 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 5.10 Estimated present value of energy benefits 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	**-28**	286	2	260
NSW	4	53	468	15	536
NSW	5	**-24**	480	9	465
NSW	6	**-6**	578	34	606
NSW	7	33	543	33	609
NSW	8	21	819	90	930
VIC	4	192	153	25	370
VIC	6	160	192	62	414
VIC	7	198	196	61	454
VIC	8	343	275	146	764
QLD	1	92	9	0	101
QLD	2	22	10	0	32
QLD	3	172	9	1	182
QLD	5	58	12	2	72
SA	4	94	237	33	364
SA	5	53	214	18	285
SA	6	40	339	86	465
WA	1	35	68	0	102
WA	3	103	80	3	186
WA	4	69	143	14	226
WA	5	36	127	8	172
WA	6	40	213	36	289
TAS	7	109	164	288	561
NT	1	1,218	3	0	1,221
NT	3	635	4	0	640
ACT	7	146	254	19	419

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 4. 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 5.11 Estimated present value of energy benefits 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	-119	596	0	478
NSW	4	-82	621	0	540
NSW	5	-90	609	0	519
NSW	6	-124	671	0	547
NSW	7	-53	699	0	646
VIC	6	-118	697	0	579
VIC	7	22	755	0	777
QLD	1	201	24	0	225
QLD	2	430	24	0	454
QLD	5	477	25	0	502
SA	5	-131	629	0	498
WA	5	-224	402	0	178
TAS	7	461	212	0	673
NT	1	1,284	11	0	1,295
ACT	7	169	472	0	641

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 4. 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 5.12 Estimated present value of energy benefits 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	-202	596	0	395
NSW	4	-167	621	0	455
NSW	5	-177	609	0	432
NSW	6	-214	671	0	457
NSW	7	-146	699	0	553
VIC	6	-233	697	0	464
VIC	7	-195	754	0	559
QLD	1	14	23	0	37

Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total
QLD	2	1	24	0	25
QLD	5	21	25	0	46
SA	5	**-131**	629	0	498
WA	5	**-224**	402	0	177
TAS	7	323	212	0	536
NT	1	695	11	0	706
ACT	7	54	470	0	524

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 4. 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.

5.3 Net impacts on individual dwellings

The net impacts for each dwelling in the sample under each policy option are provided in Table 5.13 and Table 5.14. 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 — 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 4, 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 5.13 Estimated net impacts of proposed NCC policy options for Class 1 composite dwellings across different jurisdictions and climate zones modelled ($2021)

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
Option A					
NSW	2	1,131	275	**-856**	0.2
NSW	4	2,578	607	**-1,971**	0.2
NSW	5	2,669	531	**-2,138**	0.2
NSW	6	3,007	738	**-2,269**	0.2
NSW	7	2,965	707	**-2,258**	0.2
NSW	8	5,523	1,344	**-4,178**	0.2
VIC	4	3,059	686	**-2,374**	0.2
VIC	6	3,173	698	**-2,475**	0.2
VIC	7	3,681	860	**-2,821**	0.2
VIC	8	4,829	1,200	**-3,629**	0.2
QLD	1	1,369	428	**-942**	0.3
QLD	2	680	109	**-571**	0.2
QLD	3	1,607	520	**-1,088**	0.3
QLD	5	1,738	225	**-1,513**	0.1
SA	4	1,443	476	**-967**	0.3
SA	5	974	403	**-571**	0.4
SA	6	1,683	662	**-1,021**	0.4
WA	1	638	251	**-387**	0.4
WA	3	956	341	**-615**	0.4
WA	4	1,171	240	**-931**	0.2
WA	5	712	187	**-525**	0.3
WA	6	1,420	354	**-1,066**	0.2
TAS	7	2,665	961	**-1,704**	0.4
NT	1	6,813	3,018	**-3,795**	0.4
NT	3	2,872	1,295	**-1,577**	0.5
ACT	7	1,718	524	**-1,193**	0.3
Option B					
NSW	2	1,071	260	**-811**	0.2
NSW	4	2,339	536	**-1,803**	0.2
NSW	5	2,428	465	**-1,963**	0.2
NSW	6	2,472	606	**-1,866**	0.2
NSW	7	2,614	609	**-2,004**	0.2

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
NSW	8	2,839	930	-1,909	0.3
VIC	4	1,508	370	-1,138	0.2
VIC	6	1,370	414	-956	0.3
VIC	7	1,855	454	-1,400	0.2
VIC	8	1,851	764	-1,087	0.4
QLD	1	136	101	-36	0.7
QLD	2	422	32	-389	0.1
QLD	3	374	182	-192	0.5
QLD	5	1,057	72	-986	0.1
SA	4	1,094	364	-730	0.3
SA	5	615	285	-330	0.5
SA	6	939	465	-474	0.5
WA	1	81	102	21	1.3
WA	3	400	186	-214	0.5
WA	4	1,119	226	-894	0.2
WA	5	656	172	-485	0.3
WA	6	1,035	289	-746	0.3
TAS	7	1,724	561	-1,163	0.3
NT	1	2,202	1,221	-981	0.6
NT	3	1,093	640	-453	0.6
ACT	7	1,451	419	-1,031	0.3

[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 4. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table 5.14 Estimated net impacts of proposed NCC policy options for Class 2 composite dwellings across different jurisdictions and climate zones modelled ($2021)

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
Option A					
NSW	2	2,510	478	-2,032	0.2
NSW	4	2,324	540	-1,785	0.2
NSW	5	2,612	519	-2,093	0.2

Jurisdiction	NCC climate	PVa of costs ($)	PVa of benefits ($)	Net impact ($)	BCR
NSW	6	2,435	547	**-1,889**	0.2
NSW	7	2,939	646	**-2,294**	0.2
VIC	6	3,803	579	**-3,224**	0.2
VIC	7	4,081	777	**-3,304**	0.2
QLD	1	3,212	225	**-2,988**	0.1
QLD	2	3,455	454	**-3,001**	0.1
QLD	5	3,591	502	**-3,090**	0.1
SA	5	2,363	498	**-1,865**	0.2
WA	5	2,705	178	**-2,527**	0.1
TAS	7	2,042	673	**-1,369**	0.3
NT	1	4,044	1,295	**-2,748**	0.3
ACT	7	2,029	641	**-1,387**	0.3
Option B					
NSW	2	2,204	395	**-1,809**	0.2
NSW	4	2,019	455	**-1,564**	0.2
NSW	5	2,307	432	**-1,874**	0.2
NSW	6	2,129	457	**-1,672**	0.2
NSW	7	2,634	553	**-2,081**	0.2
VIC	6	1,963	464	**-1,499**	0.2
VIC	7	2,245	559	**-1,686**	0.2
QLD	1	179	37	**-142**	0.2
QLD	2	422	25	**-397**	0.1
QLD	5	559	46	**-513**	0.1
SA	5	2,363	498	**-1,865**	0.2
WA	5	2,683	177	**-2,505**	0.1
TAS	7	1,628	536	**-1,092**	0.3
NT	1	1,956	706	**-1,250**	0.4
ACT	7	1,724	524	**-1,200**	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 4. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

5.4 Questions for stakeholders

26. Are the cost estimates presented in this chapter reasonable? If not, what are your alternative estimates and the basis for those estimates?
27. Are the changes in energy consumption presented in this chapter reasonable? If not, what are your alternative estimates and the basis for those estimates?

Economy-wide impacts 6

The previous chapter considered the impacts of the proposed NCC changes on individual dwellings. This chapter considers the overall costs and benefits of the proposed changes at the Australia-wide level.

6.1 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.

6.1.1 Change in construction costs

The aggregate capital costs associated with the proposed policy changes are summarised in Table 6.1. Most capital costs (except for inverters as discussed in Chapter 4) are only incurred during the initial dwelling construction and therefore do not create a cohort effect as is the case with energy savings.

Table 6.1 Present value of state-wide capital costs to meet the NCC 2022, $M ($2021)

	Option A	Option B
NSW	916.6	814.1
VIC	1,417.4	803.5
QLD	455.4	189.4
SA	133.3	108.2
WA	268.7	254.4
TAS	61.5	43.4
NT	64.5	28.3

	Option A	Option B
ACT	75.5	65.3
AUS	**3,392.8**	**2,306.8**

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 6.1, it is estimated that the proposed energy efficiency changes to the NCC would impose Australia-wide costs of $3.4 billion over the life of the policy under Option A and $2.3 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 appliances as a result of improving the thermal shell from 6 to 7 stars.

6.1.2 Implementation costs for industry

The industry compliance costs refer to the costs that industries affected by the proposed changes (e.g. the construction industry) would incur beyond the direct costs of energy-efficient materials and designs to comply with the amended NCC requirements. These costs include:

— Training costs — these are one-off costs incurred by industry stakeholders to familiarise themselves with the new requirements in the NCC. These costs include:
  – the time invested in familiarising themselves with the relevant aspects of the new targets
  – any fees associated with attending associated professional development seminars.
— Redesign costs — these include costs related to redesigning buildings and building products to meet the new NCC requirements.

The CBA only includes estimates of training costs. While it is recognised that industry would incur redesign costs, there are no reliable estimates of the magnitude of these costs. This is an area where the RIS is seeking input from stakeholders during the consultation period.

To calculate the training cost for industry 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 6.2. These figures 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[150,151], escalating these numbers to 2020 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.

Table 6.2 Estimated number of industry stakeholders directly affected by the proposed changes to the NCC, 2020

Occupation	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
Construction managers	13,808	11,629	7,735	2,398	3,772	716	234	596	40,888
Architects and building designers	3,558	2,997	1,993	618	972	184	60	154	10,536
Building surveyors	582	490	326	101	159	30	10	25	1,724
Thermal performance (NatHERS) assessors	2,026	1,707	1,135	352	554	105	34	87	6,000
Total	**19,974**	**16,823**	**11,189**	**3,469**	**5,457**	**1,036**	**339**	**862**	**59,148**

Note: Totals may not add up due to rounding.

Source: ACIL Allen based on information sourced from 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.

[150] 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.

[151] 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.

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).

Using assumptions in the ABCB's recent accessibility RIS[152], 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)[153]
— 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 NatHERS to understand how to use NatHERS to comply with the new requirements.

The opportunity cost of this time has been valued using estimates of hourly earnings for each of the affected occupations. For consistency, these earnings (except for NatHERS assessors[154]) have also been sourced from the ABCB's accessibility RIS, escalated to 2021 dollars and adjusted using an on-cost multiplier of 1.75 to account for non-wage labour on-costs.[155] The indicative hourly earnings used to value the time invested in training for occupations undertaking retraining are outlined in Table 6.3.

[152] Ibid.

[153] 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).

[154] Annual earnings for NatHERS assessors were sourced from the Australian Government Job Outlook (https://joboutlook.gov.au/occupations/other-architectural-building-and-surveying-technicians?occupationCode=312199) and multiplied by 0.8 to exclude taxation (this is equivalent to assuming that each of these assessors has an average tax rate of 20 per cent). Annual earnings are then converted to hourly rates assuming 230 working days per year and 7.5 hours per working day.

[155] 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).'

Table 6.3 Indicative hourly earnings for occupations requiring retraining

Occupation	$/hr 2021, excl. taxation	$/hr 2021, including on-costs
Construction managers	61.68	107.94
Architects and building designers	35.39	61.93
Building surveyors	41.46	72.55
Thermal performance (NatHERS) assessors	39.13	68.47

Note: assumes 230 working days per year and 7.5 hours per working day.

Source: ACIL Allen estimates based on information sourced from CIE 2021, Proposal to include minimum accessibility standards for housing in the National Construction Code, Decision Regulation Impact Statement; and Australian Government Job Outlook.

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 6.4.

Table 6.4 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	49.68
Architects and building designers	3.02	2.54	1.69	0.52	0.82	0.16	0.05	0.13	8.93
Building surveyors	0.51	0.43	0.29	0.09	0.14	0.03	0.01	0.02	1.51
Thermal performance (NatHERS) assessors	1.70	1.43	0.95	0.30	0.47	0.09	0.03	0.07	5.04
Total	**22.01**	**18.53**	**12.33**	**3.82**	**6.01**	**1.14**	**0.37**	**0.95**	**65.17**

Source: ACIL Allen.

6.1.3 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.

6.2 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 by the sample of dwellings modelled and deferred network investment for gas and electricity as a result of reductions in peak electricity demand and reductions in 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, since the removal of Australia's carbon pricing mechanism in 2014, 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. While it is clear that electricity generated from fossil fuels 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 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 8.1.

6.2.1 Energy savings

Table 6.5 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 5.5 to Table 5.8)

— how the housing stock grows and develops over time (see Figure 4.2 and Figure 4.3).

As shown in Table 6.5, it is estimated that under Option A electricity consumption across Australia would decrease by about 88 PJ over the period of analysis, gas would decrease by around 78 PJ and LPG and firewood use would decrease by 7.9 PJ. The estimated reduction in energy consumption under Option B would be significantly smaller for electricity, slightly higher for gas and marginally higher for LPG and firewood. In particular, under Option B, electricity is estimated to reduce by 17.4 PJ, gas by around 88 PJ and LPG and firewood by 8.0 PJ.

A negative net present value for electricity occur in NSW under Option B. Over the period modelled, electricity consumption is initially higher under the NCC 2022 policy scenarios than under the BAU, followed by savings after some appliances reach their assumed end-of-life. After this initial period, the electricity consumed is relatively lower under the NCC 2022 policy scenarios than under BAU, however, the outcomes for the earlier years have more impact on the present value of benefits than the later years, so the net result is negative.

The value of these energy reductions is also presented in Table 6.5. It is estimated that Option A would provide energy benefits to the Australian economy worth around $835 million in present value terms, and Option B would deliver around $488 million in benefits.

Table 6.5 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								
NSW	11.4	36.9	1.2	49.5	28.5	189.7	4.6	222.8
VIC	55.1	18.7	3.2	76.9	261.7	80.4	12.3	354.5
QLD	9.6	0.8	0.0	10.4	68.8	4.0	0.2	73.0
SA	2.6	5.1	0.7	8.4	15.2	23.4	2.5	41.2
WA	3.1	12.9	0.5	16.5	18.0	34.7	1.8	54.4
TAS	1.2	0.8	2.2	4.3	8.1	3.5	8.8	20.4
NT	3.3	0.0	0.0	3.3	45.0	0.0	0.0	45.1
ACT	1.2	2.9	0.1	4.3	8.9	13.7	0.6	23.2
Australia	**87.5**	**78.2**	**7.9**	**173.6**	**454.4**	**349.5**	**30.7**	**834.5**
Option B								
NSW	4.5	37.1	1.2	42.7	**-12.1**	190.4	4.6	182.8
VIC	5.9	28.7	4.4	39.0	29.3	125.5	17.1	171.9
QLD	1.6	0.8	0.0	2.4	8.7	4.0	0.1	12.8
SA	1.0	5.1	0.5	6.6	4.6	23.1	1.8	29.6
WA	2.1	12.9	0.4	15.5	11.3	34.7	1.7	47.7
TAS	0.6	0.8	1.4	2.8	3.0	3.5	5.5	11.9
NT	0.9	0.0	0.0	1.0	13.1	0.1	0.0	13.1
ACT	0.7	2.9	0.1	3.7	4.5	13.7	0.4	18.5
Australia	**17.4**	**88.3**	**8.0**	**113.7**	**62.4**	**394.9**	**31.1**	**488.4**

Note: Savings account for the rebound effect discussed in Chapter 4. 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.

6.2.2 Deferred network investment for gas and electricity

As outlined in Sections 4.5.4 and 4.5.5, 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 5.2, 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 6.6 outlines the estimated network benefits associated with the proposed changes to the NCC in present value terms over the modelled period. As shown in this table, 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.

Most states are estimated to experience overall cost reductions in both electricity and gas networks, except for:

— NSW that is estimated to experience increases in electricity network costs under both policy options. This is due to the increases in peak demand in the short-term, effectively bringing forward network investment. The associated longer-term benefit of this investment is also captured, however could not fully offset the costs incurred at the beginning of the modelled period.
— Victoria, where increases in peak demand are estimated under Option B due to fuel switching that result in an overall increase in electricity network investment. This increase is offset by deferred gas pipeline costs, resulting in a net total saving in infrastructure investment for Victoria under Option B.

Table 6.6 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	**-$9.1**	$5.6	**-$3.5**
VIC	$46.6	$2.6	$49.1
QLD	$7.3	$0.1	$7.4
SA	$0.7	$0.7	$1.3
WA	$1.4	$1.7	$3.1
TAS	$0.8	$0.1	$0.9
NT	$3.4	$0.0	$3.4
ACT	$0.4	$0.4	$0.9
Australia	**$51.4**	**$11.2**	**$62.6**
Option B			
NSW	**-$10.9**	$5.6	**-$5.3**
VIC	**-$1.9**	$4.0	$2.1
QLD	$2.3	$0.1	$2.4
SA	$0.2	$0.7	$0.9
WA	$0.2	$1.7	$1.9
TAS	$0.7	$0.1	$0.8
NT	$1.5	$0.0	$1.5
ACT	$1.2	$0.4	$1.6
Australia	**-$6.8**	**$12.6**	**$5.9**

Note: 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.

6.2.3 Reduced greenhouse gas 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 15.6 Mt CO2-e over the period 2022-2060, and by around 6.6 Mt CO2-e under Option B (see Table 6.7). The estimated present value of these savings is around $195 million under Option A and approximately $83 million under Option B.

Table 6.7 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					
NSW	0.9	2.4	0.0	3.3	42.9
VIC	7.5	1.0	0.0	8.5	103.5
QLD	1.6	0.0	0.0	1.7	22.2
SA	0.2	0.3	0.0	0.5	6.0
WA	0.2	0.7	0.0	0.9	11.9
TAS	0.0	0.0	0.0	0.1	1.0
NT	0.3	0.0	0.0	0.3	3.7
ACT	0.1	0.2	0.0	0.3	4.2
Australia	**10.9**	**4.7**	**0.0**	**15.6**	**195.3**
Option B					
NSW	0.2	2.4	0.0	2.5	33.0
VIC	0.6	1.6	0.0	2.2	26.9
QLD	0.2	0.0	0.0	0.2	2.9
SA	0.1	0.3	0.0	0.4	4.7
WA	0.1	0.7	0.0	0.9	10.6
TAS	0.0	0.0	0.0	0.1	0.7
NT	0.1	0.0	0.0	0.1	1.1
ACT	0.1	0.2	0.0	0.3	3.3
Australia	**1.3**	**5.2**	**0.0**	**6.6**	**83.1**

Note: Savings account for the rebound effect discussed in Chapter 4. Present values at 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

6.2.4 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 4, 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 use. These are outlined in Table 6.8. As shown in this table, it is estimated that Option A would provide health benefits to the Australian economy worth around $120 million in present value terms, and Option B would deliver around $13 million in benefits.

Table 6.8 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	Total
Option A				
NSW	23.5	6.4	4.9	34.8
VIC	30.1	2.8	2.3	35.2
QLD	36.8	5.1	0.1	42.0
SA	0.00	4.5	0.6	5.1
WA	0.2	0.1	1.5	1.8
TAS	0.00	0.00	0.1	0.1
NT	0.00	0.3	0.00	0.3
ACT	0.1[a]	0.00[a]	0.4	0.4
Australia	**90.7**	**19.1**	**9.8**	**119.6**
Option B				
NSW	0.2	0.1	4.9	5.2
VIC	0.3	0.1	3.5	3.9
QLD	0.3	0.1	0.1	0.5
SA	0.00	0.07	0.6	0.7
WA	0.1	0.1	1.5	1.6
TAS	0.00	0.00	0.1	0.1
NT	0.00	0.08	0.00	0.08
ACT	0.05 [a]	0.00 [a]	0.3	0.4
Australia	**1.0**	**0.51**	**11.0**	**12.5**

[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.

Note: Accounting for the rebound effect discussed in Chapter 4. Present values at 7 per cent discount rate.

Source: ACIL Allen.

6.3 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 summarised in Table 6.9. 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 6.9 indicates that, at an economy-wide level, both policy options are estimated 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:

- the use of wholesale energy prices (as a proxy of avoided resource costs) to value the benefits of reduced energy consumption, which as noted in Chapter 4, results in BCRs and NPVs that are much smaller than if retail energy prices are used
- the high capital costs for households associated with meeting the proposed energy efficiency requirements.

Details of the costs and benefits for individual states are presented in Appendix E.

Table 6.9 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Australia

	Option A	Option B
COSTS		
Households - capital (resource) costs	3,392.8	2,306.8
Industry	65.2	65.2
Government Costs	0.6	0.6
TOTAL COSTS	**3,458.6**	**2,372.6**
BENEFITS		
Households		
Electricity savings	454.4	62.4
Gas savings	349.5	394.9
LPG and firewood savings	30.7	31.1
Household subtotal	*834.5*	*488.4*
Society		
Deferred network investment for gas and electricity	62.6	5.9
Greenhouse emissions savings	195.3	83.1
Health benefits from improved air quality	119.6	12.5
Society subtotal	*377.6*	*101.5*
TOTAL BENEFITS	**1,212.1**	**589.9**
NET PRESENT VALUES		
Accounting for energy benefits only	**-2,561.5**	**-1,878.3**
Accounting for energy benefits + carbon benefits	**-2,366.1**	**-1,795.2**
Accounting for energy benefits + carbon benefits + health benefits	**-2,246.6**	**-1,782.7**
BCR (RATIO)		
Accounting for energy benefits only	0.26	0.21
Accounting for energy benefits + carbon benefits	0.32	0.24

	Option A	Option B
Accounting for energy benefits + carbon benefits + health benefits	0.35	0.25

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

6.4 Sensitivity and breakeven analysis

6.4.1 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, consistent with advice from best practice regulation guides
- industry costs — an increase in industry costs of 50 per cent and a decrease in industry costs of 50 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 and 4.5 times the price used in the central case[156]
- rebound effect — a decrease in rebound effect to zero and an increase in rebound to 30 per cent in line with some higher estimates discussed in Section 4.5.1
- 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 6.10. This table shows that:

- Lower discount rates produce a more negative result (in this case, a higher net cost to society) and higher discount rates produce a lower net cost to society. This is because higher discount rates increase the present value of both costs and benefits, but the magnitude of the cost increase more than offsets the increase in benefits.
- If industry costs are decreased or increased by 50 per cent, the NPV for the policy options changes marginally:
  - from -$2.25 billion under the initial ‘standard’ assumptions for Option A, to -$2.21 billion or -$2.28 billion (a potential change in the net impact of the scenario of around 1.5 per cent)
  - from -$1.78 billion under the initial ‘standard’ assumptions for Option B, to -$1.75 billion or -$1.82 billion (a potential change in the net impact of the scenario of around 1.9 per cent).
- If carbon prices decrease by 50 per cent, the NPV for Option A decreases by around 4 per cent, from -$2.25 billion to -$2.34 billion, and the NPV for Option B decreases by 2.3 per cent, from -$1.78 billion to -$1.82 billion.

[156] An increase of 4.5 times the prices is equivalent to a carbon price in 2022 of roughly $75 per tonne of abatement.

- If carbon prices increase by 100 per cent (i.e. if they double), the NPV for Option A improves by 8.7 per cent, from -$2.25 billion to -$2.05 billion, and the NPV for Option B improves by 4.7 per cent, from -$1.78 billion to -$1.70 billion.
- If carbon prices are 4.5 times higher (i.e. if they increase by 350%), the NPV for Option A improves by around 32 per cent, from -$2.25 billion to -$1.54 billion, and the NPV for Option B improves by around 16 per cent, from -$1.78 billion to -$1.49 billion.
- If rebound effect is assumed to be zero, the NPV for both options improves. In Option A it improves by 4.3 per cent to -$2.15 billion and in Option B it improves by 3.4 per cent to -$1.72 billion. Increasing the rebound effect has the opposite result, making both options perform worst.
- 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 7.5 per cent from -$2.25 billion to -$2.42 billion. The net losses under Option B would increase by around 6 per cent from -$1.78 billion to -$1.89 billion.
- 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 around 19 per cent from -$2.25 billion to -$2.68 billion and the net losses under Option B would increase by 15 per cent from -$1.78 billion to -$2.05 billion.

Table 6.10 Sensitivity analysis — impact of sensitivity tests on the NPV under each policy option ($M, 2021)

	Option A	Option B
NPV under standard assumptions (as per Table 6.9**)**	**-$2,247**	**-$1,783**
Discount rate		
Decrease to 3%	**- $2,149**	**- $1,839**
Increase to 10%	**- $2,193**	**- $1,693**
Industry costs [a]		
Decrease costs by 50%	**- $2,214**	**- $1,750**
Increase costs by 50%	**- $2,279**	**- $1,815**
Carbon price [a]		
Decrease price by 50%	**-$2,344**	**-$1,824**
Increase price by 100%	**-$2,051**	**-$1,700**
Increase price by 350% (4.5 times)	**-$1,536**	**-$1,492**
Rebound effect		
Decrease rebound to 0%	**- $2,150**	**-$1,723**
Increase rebound to 30%	**-$2,441**	**-$1,902**
Performance gap		
Low realisation scenario — 50% of modelled energy savings are achieved in practice	**-$2,683**	**-$2,051**

	Option A	Option B
Medium realisation scenario — 75% of modelled energy savings are achieved in practice	-$2,416	-$1,887

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

Note: All changes are modelled as changes from the central case scenario (which includes a rebound effect of 10 per cent).

Source: ACIL Allen.

6.4.2 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 NPV economy-wide is equal to zero and the BCR is one.

The results of the breakeven analysis are provided in Table 6.11. 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 five times higher under Option A and more than 15 times higher under Option B
  - the costs of upgrades would need to be almost entirely free (or around 3 to 24 per cent of the current costs)
- breakeven economy-wide
  - the wholesale energy prices would need to be more than three times higher
  - the costs of upgrades would need to be around 23 to 34 per cent of the current costs.

Table 6.11 Breakeven analysis [a]

	Option A	Option B
Breakeven in each jurisdiction		
Percentage change in wholesale energy prices to breakeven	443%	1432%
Percentage change in compliance (capital) costs to breakeven	-76%	-97%

	Option A	Option B
Breakeven economy-wide		
Percentage change in wholesale energy prices to breakeven	269%	365%
Percentage change in compliance (capital) costs to breakeven	**-66%**	**-77%**

[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: All changes are modelled as level changes applied evenly for all years, all building classes, and all jurisdictions and climate zones (i.e. not year on year change).

Source: ACIL Allen.

6.5 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), any changes in capacity in terms of new investments or retirements of existing generators, and on minimum demand levels.

While the impacts of the increased uptake of solar PV on the wholesale electricity markets in Western Australia and the Northern Territory were not specifically modelled for this RIS, it would be expected that the results would be broadly similar to those in the NEM.

The impact of the increased uptake of solar PV on the electricity grid is discussed in section 8.6.4.

6.5.1 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 (Option A).
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.

6.5.2 Assumptions

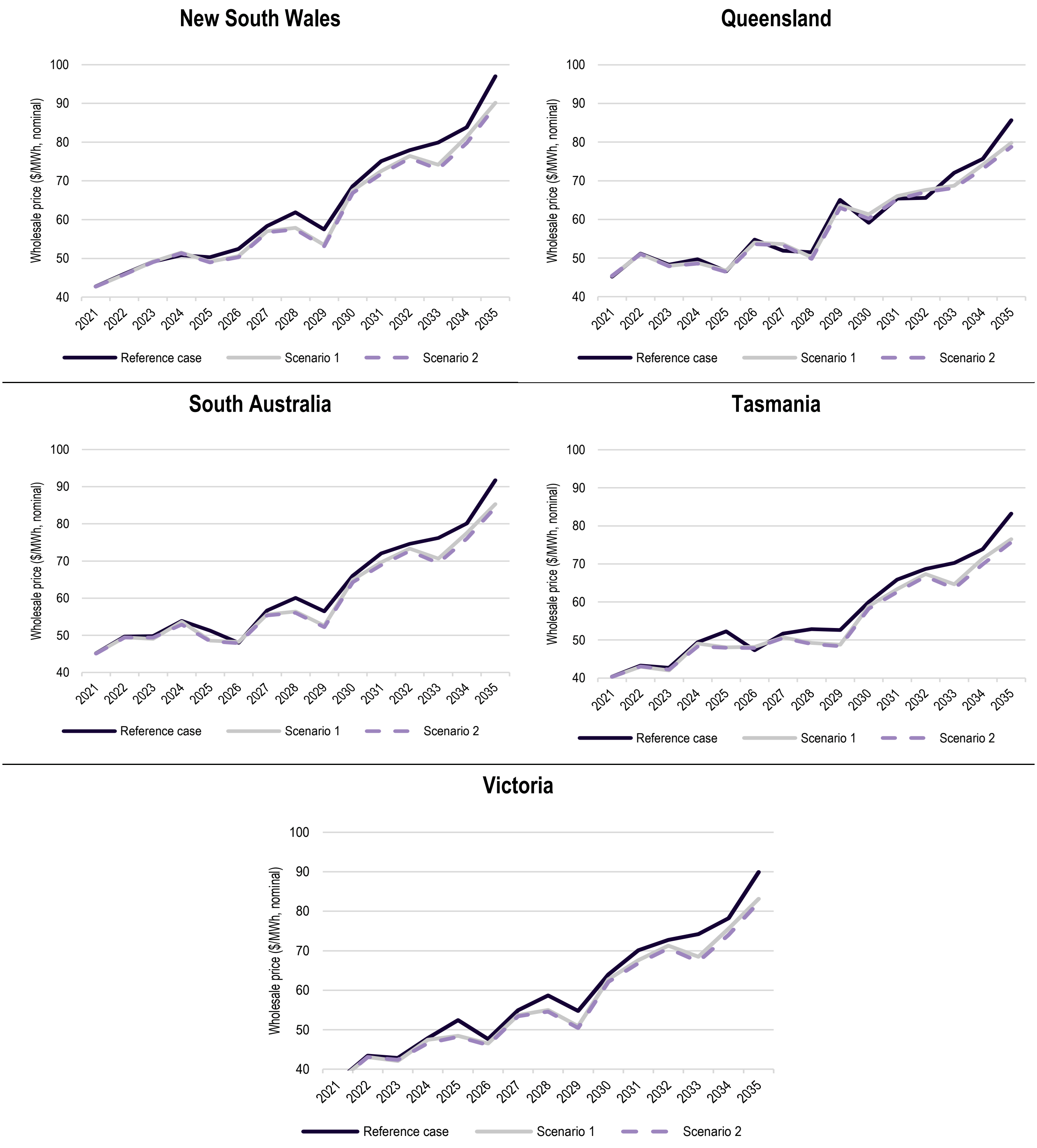
The assumptions that have been used in the wholesale electricity market modelling are provided in Appendices F and G.

6.5.3 Impacts on wholesale electricity prices

The wholesale energy market modelling projects that the wholesale electricity price will be up to 11.0 per cent lower under the proposed NCC 2022 (scenario 1) than under the reference case, as illustrated in Figure 6.1. This is due to the reduction in the energy consumed from the network and a reduction in the peak demand.

The difference in the wholesale electricity prices between scenarios 1 and 2 is barely perceptible.

Figure 6.1 Projected time weighted wholesale electricity prices, 2021-35



Source: ACIL Allen

If the solar PV that is installed under the NCC 2022 is not replaced at the end of its assumed 20 year life, the wholesale electricity prices will increase from 2042 and return to the same levels as under the reference case.

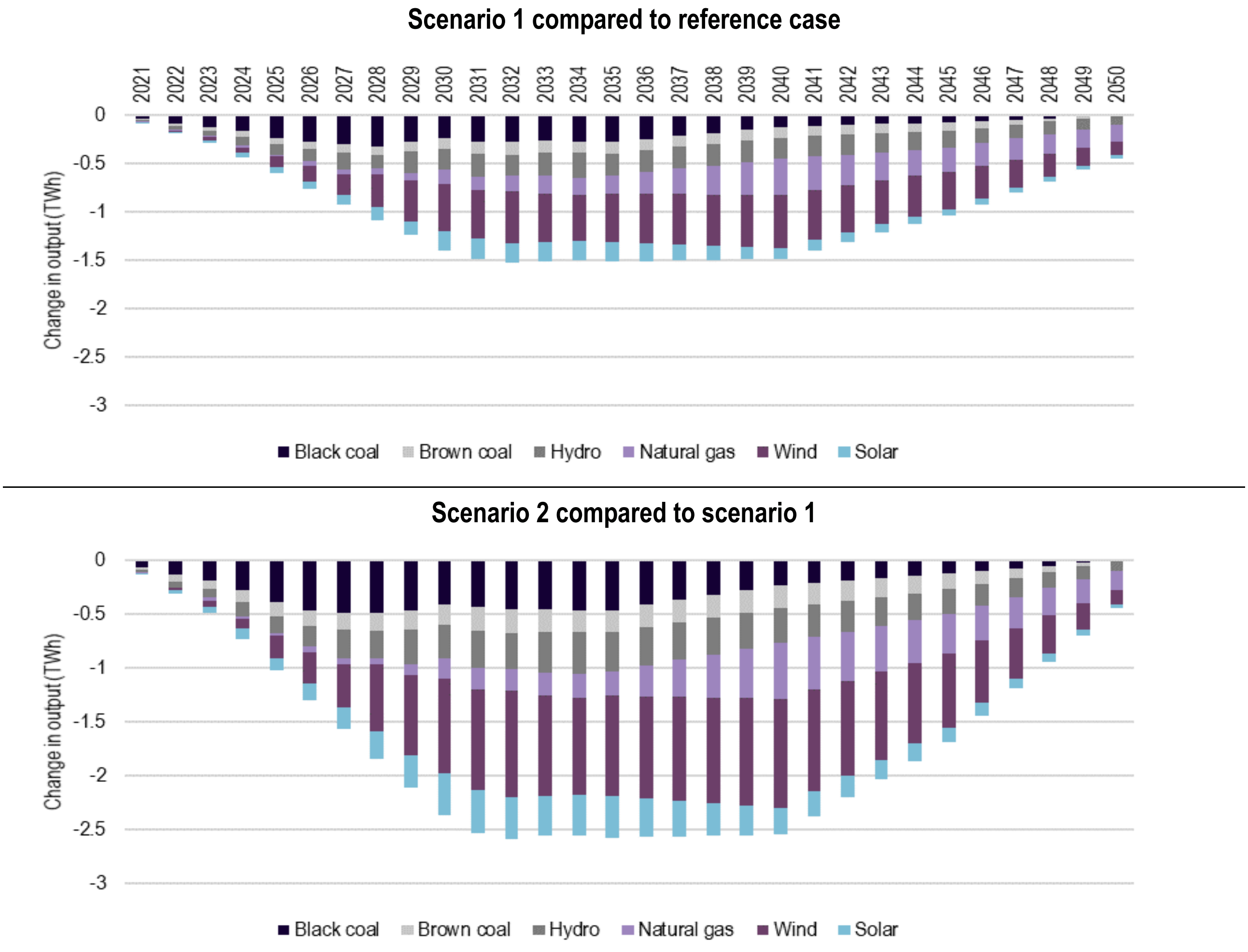
6.5.4 Impact on generator capacity and output

The wholesale energy market modelling does not project any change in generator capacity with the proposed NCC 2022.

The projected change in generator output across the NEM from 2021 to 2050 is illustrated in Figure 6.2 – 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 6.2 indicates that there is a projected reduction in output from black coal generators, brown coal generators, gas-fired generators, hydro generators, wind and solar, increasing from 2021 to 2032, and then declining from 2040. To put these reductions in perspective, the maximum reduction in generator output is 0.86 per cent in 2032 between the reference case and scenario 1 and 1.47 per cent in 2032 between the reference case and scenario 2.

Figure 6.2 Projected change in generator output across the NEM, 2021 - 2050



Source: ACIL Allen

The projected 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 prices when there is more rooftop solar PV installed under both scenarios 1 and 2.

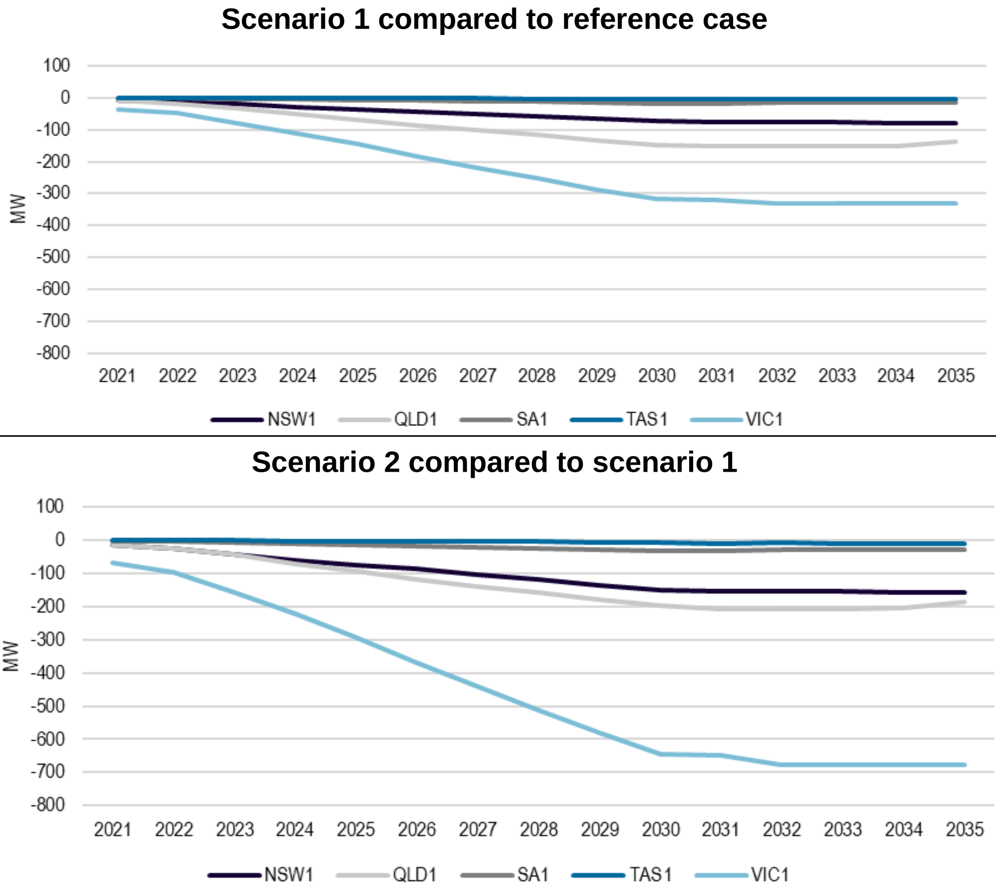
If the solar PV that is installed under the NCC 2022 is not replaced at the end of its assumed 20 year life, the output from other generators will increase. That is, the reduction in generator output, as illustrated in Figure 6.2 will reduce from 2042 and return to the output under the reference case.

6.5.5 Minimum demand levels

The projected change in minimum demand levels in the NEM jurisdictions as a result of the proposed NCC 2022 is illustrated in Figure 6.3 – the top pane illustrates the difference in the minimum demand levels between the reference case and scenario 1 (option A) and the bottom pane illustrates the difference in the minimum demand levels between the reference case and scenario 2 (option A with twice as much solar PV capacity).

The projected change in the minimum demand levels is immaterial in Tasmania and South Australia, more material in Queensland and New South Wales, and the most material in Victoria.

Figure 6.3 Projected change in minimum demand levels



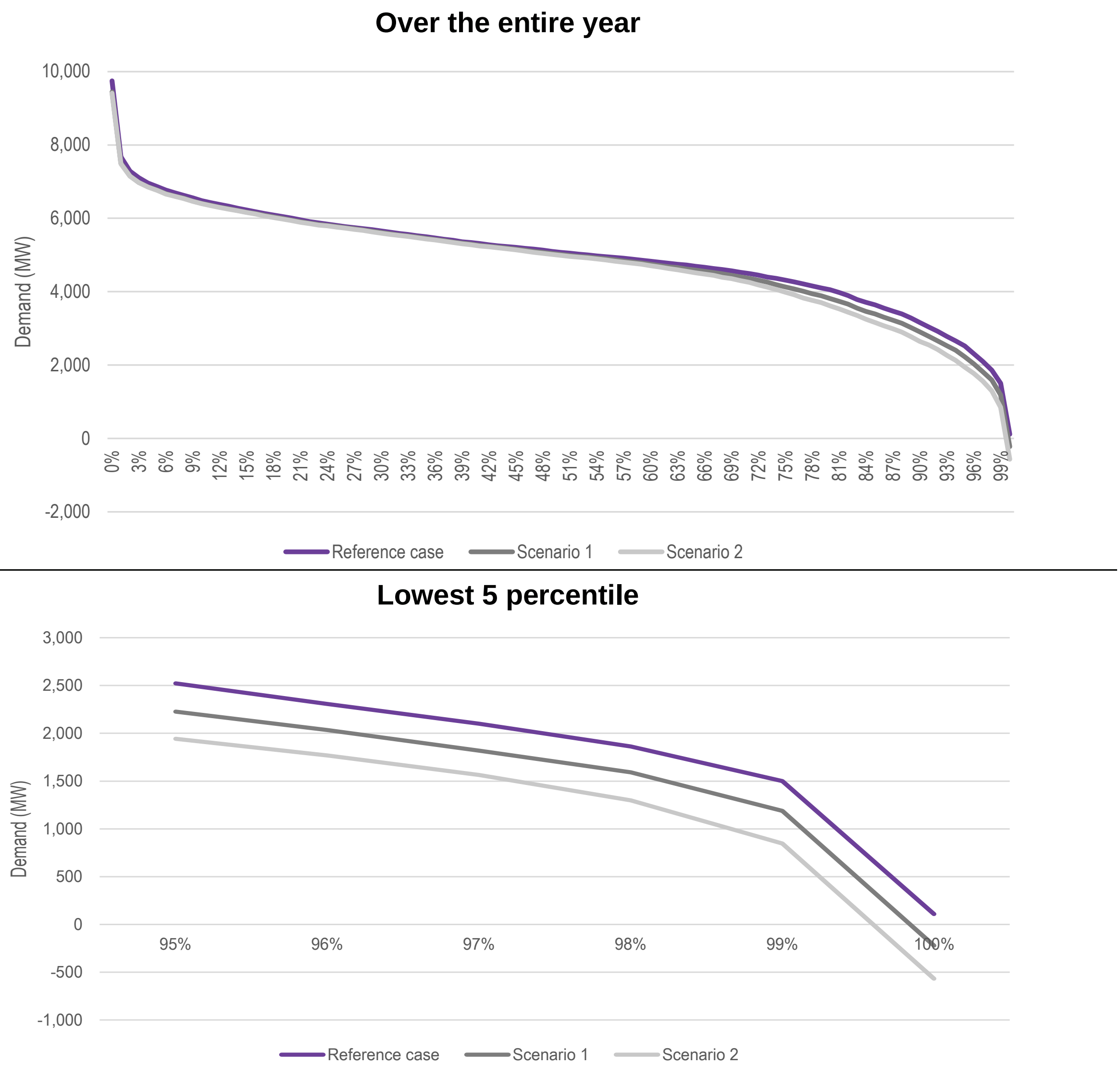
Source: ACIL Allen

The projected minimum demand levels are positive in all years in New South Wales, Queensland and Tasmania.

The projected minimum demand level in South Australia is negative from 2025 under the reference case and from 2024 under scenarios 1 and 2. In Victoria, where there is a greater requirement to install solar PV to meet the proposed NCC 2022, the projected minimum demand levels are positive under the reference case but are negative under scenario 1 from 2030 and from 2029 under scenario 2.

The load duration curve for Victoria in 2040, based on hourly data, is provided in Figure 6.4 – the top pane provides the load duration curve across the entire year and the bottom pane 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 9,744 MW, 50 per cent of the time, the load is above 5,070 MW and 95 per cent of the time, the load is above 2,522 MW.

Figure 6.4 Load duration curve, Victoria, 2040



Source: ACIL Allen

In 2040, the minimum demand in Victoria is projected to be:

— 110 MW under the reference case
— -221 MW under scenario 1
— -567 MW under scenario 2.

Under scenario 1, the minimum demand is projected to be negative for around 0.117 per cent of the year or 10 hours. Under scenario 2, the minimum demand is projected to be negative for around 0.228 per cent of the year, or 20 hours.

If the solar PV that is installed under the NCC 2022 is not replaced at the end of its assumed 20 year life, the minimum demand levels will increase from 2042, and return to the minimum demand levels under the reference case.

6.6 Questions for stakeholders

28. Can you provide estimates of the costs to redesign buildings and alter building products that would be incurred by industry to meet the proposed new NCC requirements?
29. Are there any other costs (e.g. transition costs) not identified for builders and other stakeholders in transitioning to the proposed new NCC requirements?
30. In terms of the realisation of the energy savings, which of the scenarios modelled is most likely to occur if the proposed changes are made to the NCC? What factors will affect the realisation of the modelled results?
31. Do you agree with the conclusions reached for the energy market impacts (relating to wholesale prices, generator capacity and minimum demand levels)?
32. Are there any other assumptions/parameters that should be included in the sensitivity/breakeven analysis? If so, what values should be tested and why?
33. What is your view on the most appropriate value for avoided greenhouse gas emissions (carbon price)?

Impacts on households 7

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.

7.1 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 7.1 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 avoided 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 7.1 show a more positive result for households than those results in Section 5.3. (which show the impacts on individual dwellings from a societal perspective — i.e. measured using wholesale energy prices and avoided network investment). However:

— Under Option A, the proposed changes are estimated to still result in net costs for most households in both Class 1 and Class 2 dwellings across Australia. That is, the benefits received by households in these dwellings from the additional energy efficiency measures installed are not sufficient to cover the additional costs incurred to implement these measures. Households in Class 1 dwellings in South Australia, Western Australia and the Northern Territory and in Class 2 dwellings in Tasmania and the ACT are estimated to experience net benefits from the proposed changes.

- Under Option B, it is estimated that the proposed changes would also result in net costs for most households in Class 1 in South Australia and Western Australia and households in Class 2 dwellings in Tasmania and the ACT.

Table 7.2 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 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, consistent with the overall approach taken in the RIS of accounting for the costs of thermal bridging mitigation measures for steel buildings but not their benefits in terms of reductions in energy consumption (outlined in Section 4.3.3), the results of the distributional analysis in Table 7.1 and Table 7.2 include the costs of thermal bridging mitigation measures but not their benefits.

However, in reality households would benefit from reduced energy bills from the thermal bridging mitigation measures. To understand if the inclusion of these benefits would be material to the household results (that is, to explore if some or all of the households outlined in Table 7.1 would achieve a positive NPV or a BCR above one if the thermal bridging benefits were accounted for) we conducted the indicative analysis outlined in Table 7.3.

The first column in Table 7.3 shows our assumption about the maximum increase in steel frame dwellings' energy efficiency from thermal bridging mitigation measures (set at 30 per cent). This is based on research by TIC noted in Section 4.3.3 that:

- estimates that thermal bridging results in a loss of performance of between 0.7 and 1.5 NatHERS stars more in steel framed buildings than timber framed buildings[157]
- 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.

Given this, we believe that is reasonable to assume that the maximum increase in energy efficiency that a steel framed dwelling would experience after implementing the thermal bridging mitigation measures in the NCC 2022 would be 30 per cent.

The second column in Table 7.3 shows the proportion of dwellings across states that are steel framed.[158] Taking into account this proportion and the maximum assumed savings that steel framed buildings would achieve, the third column in Table 7.3 shows an estimate of the maximum increase in energy savings that would occur across all buildings if thermal bridging benefits were included in the household analysis. In houses these increases range from 0 per cent in Tasmania and the ACT (where there are no steel framed dwellings), to 26 per cent in the Northern Territory where a significant proportion of dwellings are steel framed. In apartments these increases range from 0 per cent in Tasmania to 11 per cent in Western Australia.

[157] This is relevant because, as noted in Section 4.3.3, the thermal bridging mitigation measures proposed for NCC 2022 have been designed to ensure that dwellings with steel frames achieve a similar performance to timber-framed dwellings, not to eliminate thermal bridging issues.

[158] Additional discussion about this is provided in Section 4.4.4.

The last two columns in Table 7.3 show the percentage increase in the present value of energy bill savings required for the proposed changes to breakeven at a household level (i.e. to fully offset the costs of the proposed NCC changes). As shown in these columns, it is estimated that in all cases except for houses in the Northern Territory under Option B, the required increases in energy bill savings for the policy to breakeven are higher than the maximum increase in energy savings that are likely to be achieved if thermal bridging benefits were included in the analysis.

In summary, this analysis shows that including thermal bridging benefits in the distributional analysis would most likely not be enough to result in positive NPVs or at least a BCR of one for most households under both policy options. The exception is for households in buildings in the Northern Territory under Option B where the inclusion of thermal bridging benefits may be enough to achieve a positive NPV.

As noted above, this analysis was conducted to estimate the likely magnitude of the impacts of including thermal bridging benefits in the distributional analysis and is indicative only. Assessing the effects of including thermal bridging benefits more accurately would require re-modelling the impacts of the NCC 2022 based on a different set of energy flows from EES.

Table 7.1 Estimated distributional impacts by household, $ per household (present value, $2021)

	Option A				Option B			
	Capital costs ($)	Energy bill savings ($)	Net bill savings ($, household NPV)	Household BCR	Capital costs ($)	Energy bill savings ($)	Net bill savings ($, household NPV)	Household BCR
Class 1								
NSW	3,243	2,463	-780	0.76	2,817	1,928	-889	0.68
VIC	4,356	3,013	-1,343	0.69	2,355	1,326	-1,030	0.56
QLD	979	630	-349	0.64	545	174	-372	0.32
SA	1,478	1,951	473	1.32	1,051	1,342	291	1.28
WA	1,045	1,422	377	1.36	951	1,263	312	1.33
TAS	3,402	2,961	-441	0.87	2,357	1,584	-773	0.67
NT	7,830	9,693	1,862	1.24	3,211	3,064	-148	0.95
ACT	2,292	2,200	-91	0.96	1,995	1,706	-289	0.86
Australia	2,547	2,026	-521	0.80	1,704	1,197	-507	0.70
Class 2								
NSW	2,855	1,812	-1,043	0.63	2,516	1,347	-1,168	0.54
VIC	4,226	1,521	-2,705	0.36	2,182	1,066	-1,115	0.49
QLD	3,834	1,861	-1,973	0.49	464	139	-325	0.30
SA	2,626	2,319	-306	0.88	2,626	2,319	-306	0.88
WA	3,000	1,468	-1,532	0.49	2,975	1,463	-1,513	0.49
TAS	2,269	3,128	859	1.38	1,809	2,452	644	1.36
NT	4,493	2,612	-1,880	0.58	2,174	1,382	-792	0.64
ACT	2,254	2,693	439	1.19	1,916	2,107	192	1.10

	Option A				Option B			
	Capital costs ($)	Energy bill savings ($)	Net bill savings ($, household NPV)	Household BCR	Capital costs ($)	Energy bill savings ($)	Net bill savings ($, household NPV)	Household BCR
Australia	3,376	1,786	-1,590	0.53	2,051	1,132	-919	0.55

Note: these estimates use retail energy prices and refer to dwellings built in 2022. Present values calculated using a 7 per cent discount rate. 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 7.2 Estimated average energy savings per household in 2022 ($2021)

	Option A				Option B			
	Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
Class 1								
NSW	14	213	2	229	-36	214	2	180
VIC	237	9	4	250	53	56	6	116
QLD	60	6	0	66	8	6	0	14
SA	64	108	3	176	5	106	2	114
WA	41	92	1	134	23	92	1	116
TAS	186	64	46	296	46	64	29	138
NT	925	0	0	925	278	2	0	280
ACT	109	97	3	209	54	97	2	152
Class 2								
NSW	-67	265	0	198	-121	265	0	144
VIC	-95	231	0	136	-127	231	0	104

	Option A				Option B			
	Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
QLD	215	16	0	230	**-2**	16	0	14
SA	**-79**	333	0	254	**-79**	333	0	254
WA	**-141**	331	0	189	**-142**	331	0	188
TAS	249	95	0	344	171	95	0	266
NT	251	8	0	259	170	8	0	177
ACT	91	200	0	291	24	200	0	224

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 7.3 Indicative analysis of the potential impact of including energy savings associated with thermal bridging mitigation measures for steel framed buildings in the distributional analysis

	Assumed maximum increase in steel framed dwellings' energy efficiency from thermal bridging mitigation measures	Percentage of buildings that are steel framed	Percentage increase in energy savings across all buildings if thermal bridging benefits were included	Percentage increase in present value of energy bill savings required to break even at a household level [a]	
				Option A	Option B
HOUSES					
NSW	30%	14%	4%	32%	46%
VIC	30%	11%	3%	45%	78%
QLD	30%	18%	5%	55%	214%
SA	30%	13%	4%	**N/A**	**N/A**
WA	30%	12%	4%	**N/A**	**N/A**
TAS	30%	0%	0%	15%	49%
NT	30%	85%	26%	**N/A**	**5%**
ACT	30%	0%	0%	4%	17%
UNITS					
NSW	30%	4%	1%	58%	87%
VIC	30%	2%	1%	178%	105%
QLD	30%	1%	0.3%	106%	234%
SA	30%	7%	2%	13%	13%
WA	30%	35%	11%	104%	103%
TAS	30%	0%	0%	**N/A**	**N/A**
NT	30%	7%	2%	72%	57%
ACT	30%	7%	2%	**N/A**	**N/A**

[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). The breakeven point is calculated based on the present value of costs and benefits by dwelling by state outlined in Table 7.1.

Note: N/A refers to dwellings in Table 7.1 for which the BCR was already equal or above, and hence do not need to increase energy bill savings to break even.

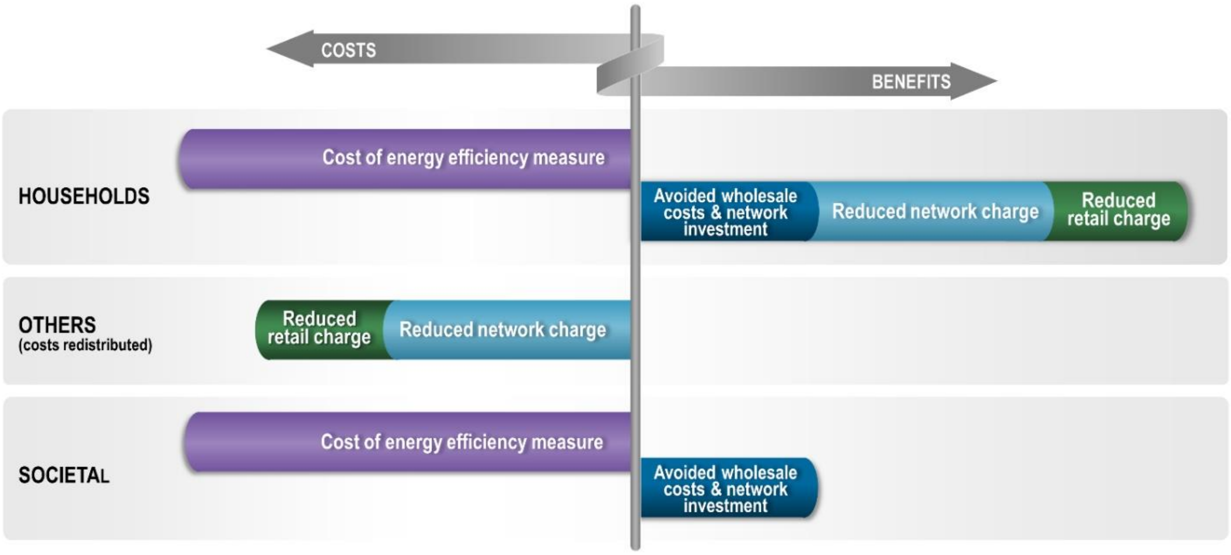
Source: ACIL Allen.

7.1.1 Understanding distributional impacts

It may appear odd that the modelled 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 costs and energy 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 7.1.

Figure 7.1 Redistribution of costs and benefits



Note: The scale of impacts are illustrative only.
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 avoided network investment (as a proxy for avoided resource costs), which is why it is used in this 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. Because the impact analysis has to consider all net impacts, including these transfers, at the society level, a large part of the benefit to households must be offset in headline net present value results when assessing the policy overall.

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.[159]

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.

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, ie, reduction in network and wholesale costs.[160]

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. [161]

7.2 Housing affordability

As illustrated in Figure 7.2, 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.

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

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

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

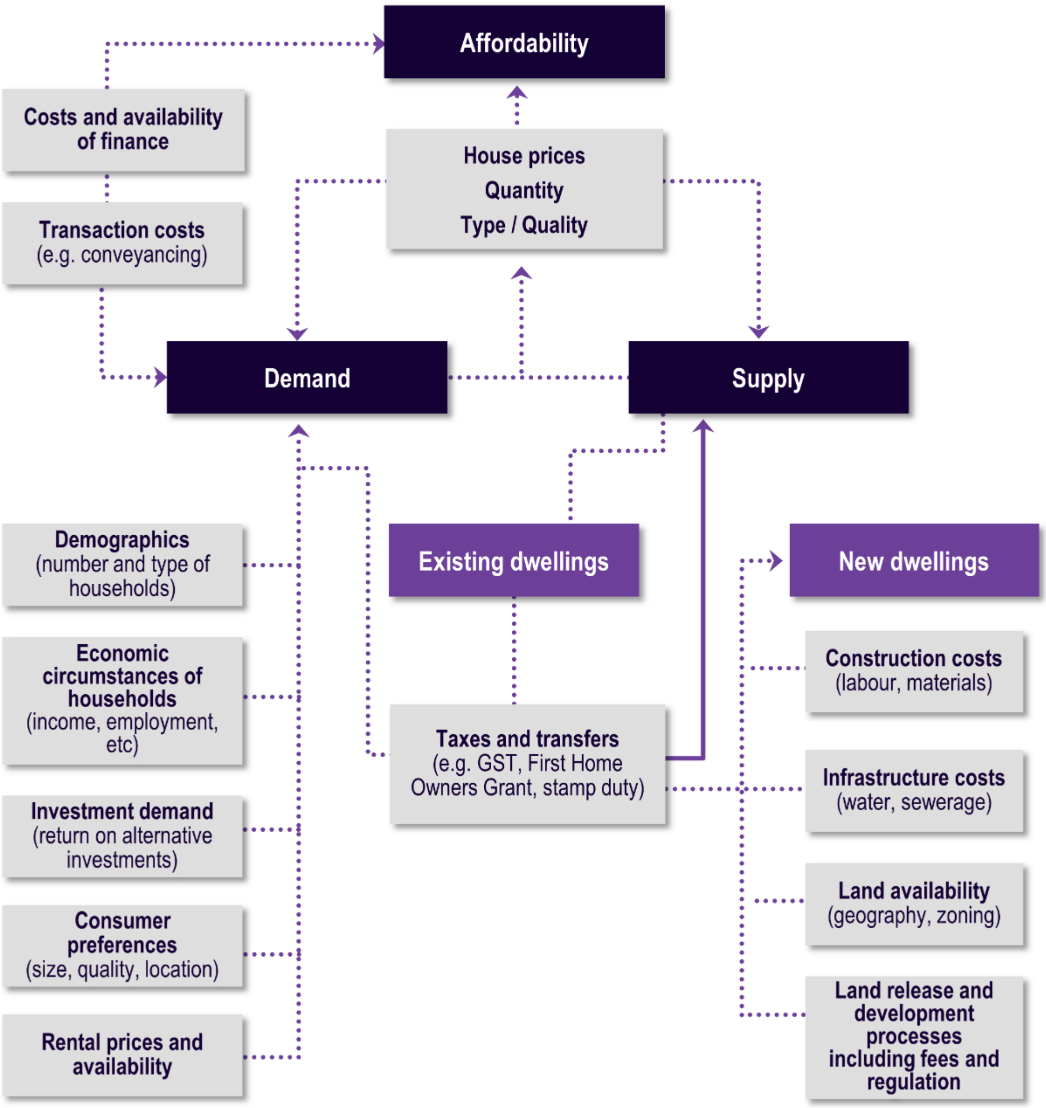
[161] Ibid, page 15.

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.

Figure 7.2 Factors affecting housing affordability



Source: Adapted from National Housing Supply Council (NHSC) 2010, 2nd State of Supply Report, Canberra, April 2010.

7.2.1 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 7.4 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.[162] 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 Western Australia) and 1.6 per cent (in the Northern Territory) for houses, and between 0.6 per cent (in NSW and Victoria) and 1.7 per cent (in the Northern Territory) for apartments
- under Option B, between 0.1 per cent (in Western Australia and Queensland) and 0.6 per cent (in Tasmania and the Northern Territory) for houses, and between 0.1 per cent (in Queensland) and 1.2 per cent (in the Northern Territory) for apartments.

Table 7.4 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	$700,000	$703,243	0.5%	$700,000	$702,817	0.4%
VIC	$630,000	$634,356	0.7%	$630,000	$632,355	0.4%
QLD	$500,000	$500,979	0.2%	$500,000	$500,545	0.1%
SA	$435,000	$436,478	0.3%	$435,000	$436,051	0.2%
WA	$458,000	$459,045	0.2%	$458,000	$458,951	0.2%
TAS	$401,500	$404,902	0.8%	$401,500	$403,857	0.6%
NT	$460,000	$467,830	1.7%	$460,000	$463,211	0.7%
ACT	$730,000	$732,292	0.3%	$730,000	$731,995	0.3%
Apartments						
NSW	$665,000	$667,855	0.4%	$665,000	$667,516	0.4%
VIC	$558,000	$562,226	0.8%	$558,000	$560,182	0.4%

[162] 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.

State/Territory	Option A			Option B		
	Current dwelling price	Dwelling price under NCC 2022	% Change	Current dwelling price	Dwelling price under NCC 2022	% Change
QLD	$391,000	$394,834	1.0%	$391,000	$391,464	0.1%
SA	$370,000	$372,626	0.7%	$370,000	$372,626	0.7%
WA	$360,000	$363,000	0.8%	$360,000	$362,975	0.8%
TAS	$355,000	$357,269	0.6%	$355,000	$356,809	0.5%
NT	$300,000	$304,493	1.5%	$300,000	$302,174	0.7%
ACT	$457,500	$459,754	0.5%	$457,500	$459,416	0.4%

Note: Median house prices as at December quarter 2020 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, the cost of building a house in NSW went up by 2.1 per cent from December 2019 to December 2020.[163] 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). In contrast, the cost of building a house in the Northern Territory went up by 1.2 per cent over the same period, which is lower than the highest expected increase in house prices due to compliance with the proposed NCC requirements in this jurisdiction (1.7 per cent for 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 7.5 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 7.5, it is estimated that the increases in repayments range:

- under Option A:
  - from $21 per annum (or around 41 cents per week) for a house in Western Australia, to $327 per annum (or around $6.30 per week) for a house in the Northern Territory
  - from $136 per annum (or around $2.60 per week) for an apartment in the ACT, to $252 per annum (or around $4.85 per week) for an apartment in Queensland
- under Option B:
  - from $17 per annum (or around 30 cents per week) for a house in Western Australia, to $167 per annum (or around $3.20 per week) for a house in NSW
  - from $24 per annum (or around 50 cents per week) for an apartment in Queensland, to $158 per annum (or around $3 per week) for an apartment in NSW.

[163] ABS 2021, *Producer Price Indexes, Australia, Cat. No. 6427.0, Table 17. Output of the Construction industries, subdivision and class index numbers*, March.

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 7.5. 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, while households in apartments in South Australia, Tasmania, the Northern Territory and the ACT would also experience net benefits in the first year, households in apartments in NSW, Victoria, Queensland and Western Australia would experience net costs in the first year.
— Under Option B, 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, while households in apartments in South Australia, Tasmania, the Northern Territory and the ACT would also experience net benefits in the first year, households in apartments in NSW, Victoria, Queensland and Western Australia would experience net costs in the first year.

Notably, over time, as utility prices changes, these impacts would change.[164]

[164] 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 7.7**.

Table 7.5 Estimated impact of capital outlays to comply with proposed NCC requirements on mortgage repayments

State/ territory	Option A: Annual mortgage payments – Currently ($)	Option A: Annual mortgage payments – Under NCC 2022 ($)	Option A: Annual mortgage payments – Change ($)[a]	Option A: Offset (savings) from lower utility bills in 2022 ($)	Option A: Net impact ($)[b]	Option B: Annual mortgage payments – Currently ($)	Option B: Annual mortgage payments – Under NCC 2022 ($)	Option B: Annual mortgage payments – Change ($)[a]	Option B: Offset (savings) from lower utility bills in 2022 ($)	Option B: Net impact ($)[b]
Houses										
NSW	$31,172	$31,317	$144	$229	$85	$31,172	$31,298	$125	$180	$55
VIC	$28,055	$28,249	$194	$250	$56	$28,055	$28,160	$105	$116	$11
QLD	$22,266	$22,310	$44	$66	$22	$22,266	$22,290	$24	$14	**-$10**
SA	$19,371	$19,437	$66	$176	$110	$19,371	$19,418	$47	$114	$67
WA	$20,396	$20,442	$47	$134	$88	$20,396	$20,438	$42	$116	$74
TAS	$17,880	$18,031	$152	$296	$145	$17,880	$17,985	$105	$138	$33
NT	$20,485	$20,833	$349	$925	$576	$20,485	$20,628	$143	$280	$137
ACT	$32,508	$32,610	$102	$209	$107	$32,508	$32,597	$89	$152	$63
Apartments										
NSW	$29,614	$29,741	$127	$198	$71	$29,614	$29,726	$112	$144	$32
VIC	$24,849	$25,037	$188	$136	**-$52**	$24,849	$24,946	$97	$104	$7
QLD	$17,412	$17,583	$171	$230	$59	$17,412	$17,433	$21	$14	**-$7**
SA	$16,477	$16,594	$117	$254	$138	$16,477	$16,594	$117	$254	$138
WA	$16,032	$16,165	$134	$189	$56	$16,032	$16,164	$132	$188	$56
TAS	$15,809	$15,910	$101	$344	$243	$15,809	$15,889	$81	$266	$185

State/ territory	Option A					Option B				
	Annual mortgage payments			Offset (savings) from lower utility bills in 2022 ($)	Net impact ($)[b]	Annual mortgage payments			Offset (savings) from lower utility bills in 2022 ($)	Net impact ($)[b]
	Currently ($)	Under NCC 2022 ($)	Change ($)[a]			Currently ($)	Under NCC 2022 ($)	Change ($)[a]		
NT	$13,360	$13,560	$200	$259	$58	$13,360	$13,456	$97	$177	$81
ACT	$20,373	$20,474	$100	$291	$190	$20,373	$20,459	$85	$224	$139

[a] Negative changes denote a decrease in mortgage repayments.

[b] 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).

Note: Based on median house price data from the December Quarter 2020 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 2.80 per cent p.a. (as at 31 December 202, sourced from the Reserve Bank of Australia (RBA)) and a 25 year repayment period. Includes the impacts on house prices outlined in Table 7.4. Totals may not add up due to rounding.

Source: ACIL Allen.

7.2.2 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.[165]

— **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 7.4.
2. Second, we estimated the impact of the proposed NCC requirements on household disposable income. These impacts are outlined in Table 7.6. 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 7.6 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.

165 These are the same indicators used in the NCC 2022 RIS.

- 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). 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 7.6 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.

Table 7.6 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	$85,144	$87,607	2.9%	$85,373	0.3%	$85,144	$87,072	2.3%	$85,324	0.2%
VIC	$86,371	$89,384	3.5%	$86,621	0.3%	$86,371	$87,697	1.5%	$86,487	0.1%
QLD	$81,135	$81,765	0.8%	$81,201	0.1%	$81,135	$81,309	0.2%	$81,150	0.02%
SA	$68,547	$70,497	2.8%	$68,723	0.3%	$68,547	$69,889	2.0%	$68,661	0.2%
WA	$86,834	$88,256	1.6%	$86,968	0.2%	$86,834	$88,097	1.5%	$86,951	0.1%
TAS	$63,994	$66,955	4.6%	$64,290	0.5%	$63,994	$65,578	2.5%	$64,132	0.2%
NT	$104,586	$114,279	9.3%	$105,510	0.9%	$104,586	$107,650	2.9%	$104,866	0.3%
ACT	$119,305	$121,505	1.8%	$119,513	0.2%	$119,305	$121,011	1.4%	$119,457	0.1%
Apartments										
NSW	$85,144	$86,957	2.1%	$85,342	0.2%	$85,144	$86,492	1.6%	$85,289	0.2%
VIC	$86,371	$87,893	1.8%	$86,507	0.2%	$86,371	$87,438	1.2%	$86,475	0.1%
QLD	$81,135	$82,996	2.3%	$81,366	0.3%	$81,135	$81,274	0.2%	$81,149	0.02%
SA	$68,547	$70,866	3.4%	$68,801	0.4%	$68,547	$70,866	3.4%	$68,801	0.4%
WA	$86,834	$88,302	1.7%	$87,024	0.2%	$86,834	$88,297	1.7%	$87,023	0.2%
TAS	$63,994	$67,122	4.9%	$64,338	0.5%	$63,994	$66,446	3.8%	$64,260	0.4%
NT	$104,586	$107,198	2.5%	$104,844	0.2%	$104,586	$105,968	1.3%	$104,763	0.2%

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
ACT	$119,305	$121,997	2.3%	$119,595	0.2%	$119,305	$121,412	1.8%	$119,528	0.2%

[a] Median household income (that is, the midpoint when all people are ranked in ascending order of income) for each state and territory in 2020 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.

Source: ACIL Allen

Affordability impacts

Table 7.7 and Table 7.8 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 7.7 would remain broadly the same for all households analysed across both options. 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 minor (a percentage point in all cases). 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 7.8 are estimated to increase slightly for:

— households in houses in Queensland and South Australia and households in apartments in Queensland, Western Australia and Tasmania under Option A

— households in houses in South Australia and households in apartments in Western Australia and Tasmania 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 7.7 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	37%	36%	37%	37%	36%	37%
VIC	32%	32%	**33%**	32%	32%	33%
QLD	27%	27%	27%	27%	27%	27%
SA	28%	28%	28%	28%	28%	28%
WA	23%	23%	**24%**	23%	23%	24%
TAS	28%	27%	28%	28%	27%	28%
NT	20%	18%	20%	20%	19%	20%
ACT	27%	27%	27%	27%	27%	27%
Apartments						
NSW	35%	34%	35%	35%	34%	35%
VIC	29%	28%	29%	29%	29%	29%
QLD	21%	21%	**22%**	21%	21%	21%
SA	24%	23%	24%	24%	23%	24%
WA	18%	18%	**19%**	18%	18%	19%
TAS	25%	24%	25%	25%	24%	25%
NT	13%	13%	13%	13%	13%	13%
ACT	17%	17%	17%	17%	17%	17%

[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.

Note: Cells highlighted in red denote a decrease in affordability. Based on median house price data from the December Quarter 2020 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 2.80 per cent p.a. (as at 31 December 2020, sourced from RBA) and a 25 year repayment period.

Source: ACIL Allen.

Table 7.8 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	8.2	8.0	8.2	8.2	8.1	8.2
VIC	7.3	7.1	7.3	7.3	7.2	7.3
QLD	6.2	6.1	**6.2**	6.2	6.2	6.2
SA	6.3	6.2	**6.4**	6.3	6.2	**6.4**
WA	5.3	5.2	5.3	5.3	5.2	5.3
TAS	6.3	6.0	6.3	6.3	6.2	6.3
NT	4.4	4.1	4.4	4.4	4.3	4.4
ACT	6.1	6.0	6.1	6.1	6.0	6.1
Apartments						
NSW	7.8	7.7	7.8	7.8	7.7	7.8
VIC	6.5	6.4	6.5	6.5	6.4	6.5
QLD	4.8	4.8	**4.9**	4.8	4.8	4.8
SA	5.4	5.3	5.4	5.4	5.3	5.4
WA	4.1	4.1	**4.2**	4.1	4.1	**4.2**
TAS	5.5	5.3	**5.6**	5.5	5.4	**5.6**
NT	2.9	2.8	2.9	2.9	2.9	2.9
ACT	3.8	3.8	3.8	3.8	3.8	3.8

[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.

Note: Cells highlighted in red denote a decrease in affordability. Based on median house price data from the December Quarter 2020 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 Table 7.6 and the impacts on house prices are outlined in Table 7.4.

Source: ACIL Allen.

7.3 Questions for stakeholders

34. What are the implications of these findings for social equity and the problem of split incentives?

Other impacts 8

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.

8.1 Non-quantified benefits

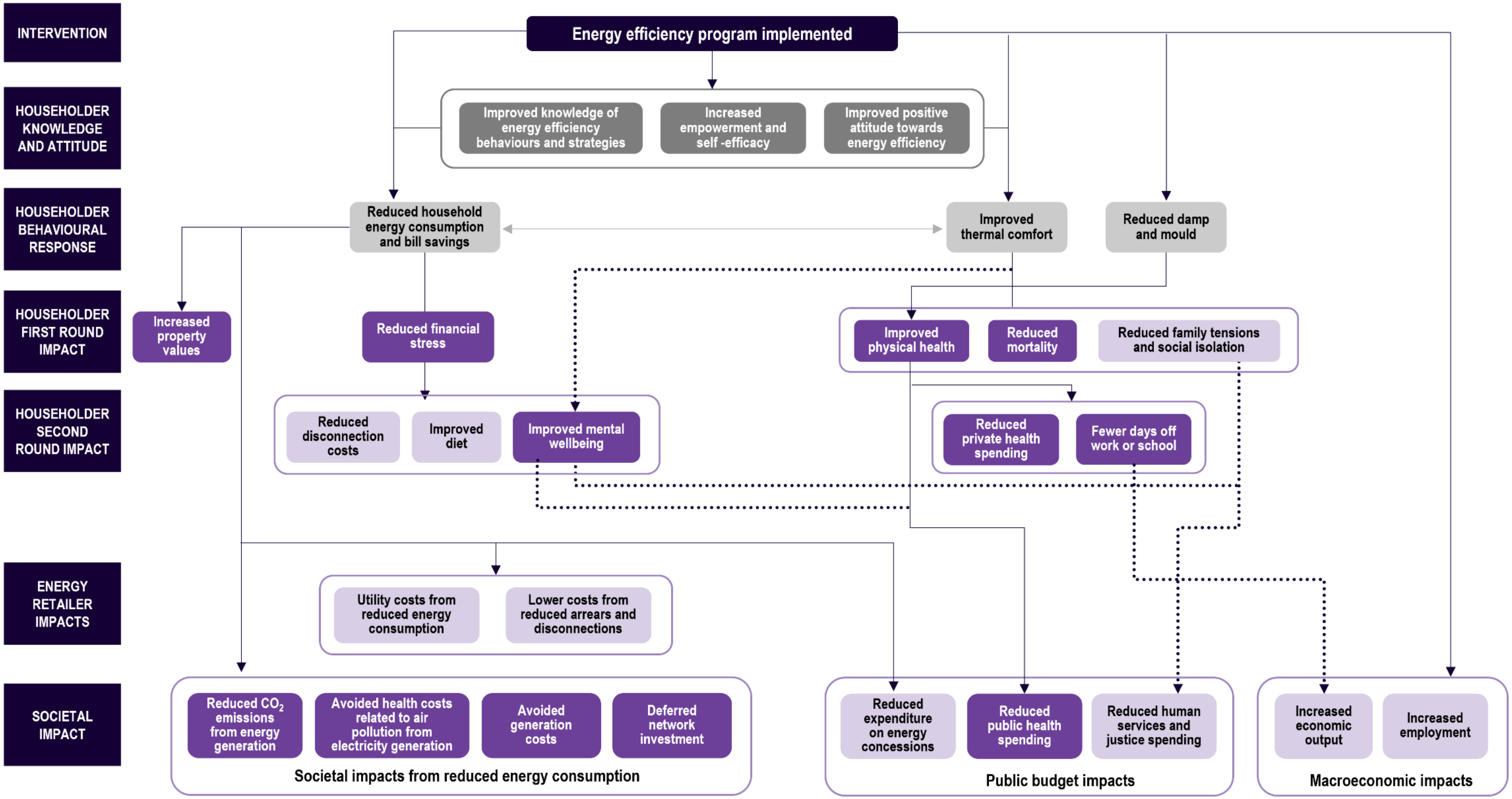
In addition to the impacts quantified in the CBA of the proposed new energy efficiency requirements in the NCC, there are a number of other impacts (both costs and benefits) associated with energy efficiency – both private and public that cannot be quantified due to a lack of existing data for the Australian context. These multiple impacts were mapped in our report *Assessment Framework for the Multiple Impacts of Household Energy Efficiency* (2017) (see Figure 8.1) and include the impacts of energy efficiency on:

— health[166] and wellbeing
— the energy system
— the overall economy
— other participant benefits.

These benefits are briefly discussed in the sections below.

[166] As noted in section 4.5.7, health benefits are partially modelled.

Figure 8.1 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.

8.1.1 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[167] 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.

The health effects of proposed changes in the NCC through pathways 1) and 2) above are likely to be immaterial as 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. 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:[168]

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[167] IEA 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency.

[168] 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.

> [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 an increase from a 6 to 7 star rating as proposed for the NCC 2022 is unlikely to have a material effect in the mortality related to extreme weather events. The health and wellbeing benefits associated with residential energy efficiency are more substantial when comparing the proposed energy efficiency provisions in the NCC 2022 with older building stock.

While the proposed increase to 7 stars is unlikely to have a material effect in the health of a dwelling's occupants, it would deliver comfort with less reliance on heating and cooling. Indeed, as noted by NatHERS[169], 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 in Section 7.1, 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.

8.1.2 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 greenhouse gas emissions is not material relative to global greenhouse gas 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 increases or decreases in the peak demand for electricity relative to the total peak demand for electricity, with the impact varying by jurisdiction. Accordingly, the proposed provisions for the NCC 2022 impacts will not have a material impact on the likelihood of blackouts due to demand exceeding supply.

The impact of proposed changes in the NCC on the consequences of extreme weather are likely to be immaterial as 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. An increase from a 6 to 7

[169] Department of the Environment and Energy (DoEE) 2019, *NatHERS assessor handbook*, Canberra.

star rating as proposed for the NCC 2022 is unlikely to have a material effect on the consequences of extreme weather events.

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.

8.1.3 Energy system

As noted in our 2017 report[170], 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[171,172]:

— improved system reliability
— enhanced capacity adequacy
— better ability to manage peak demand (as discussed in section 8.1.2)
— opportunities to defer generation and network infrastructure investments (these have been quantified for this RIS and outlined in Section 6.2.2)
— 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[173].

As discussed in section 6.5.3, the wholesale energy market modelling projects that the wholesale electricity price will be up to 11.0 per cent lower under the proposed changes to the energy efficiency requirements in the NCC 2022. These reductions may flow through to consumers through lower retail electricity prices, although they will be offset by increases in network charges with the fixed network costs recovered over a smaller energy base.

[170] 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.

[171] 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/.

[172] IEA 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency.

[173] 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/.

8.1.4 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[174].

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.

8.1.5 Other participant benefits

As noted by ACIL Allen[175] 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.[176,177]

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174 IEA 2015, *Capturing the Multiple Benefits of Energy Efficiency*, November, https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency.

175 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.

176 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

177 GEER Australia 2017, *Power Shift Project Two Deliverable 1: Overview of Energy Efficiency Co-Benefit*, Group of Energy Efficiency Researchers Australia.

8.2 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 4.3.3. 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.

8.3 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.

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.

8.4 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.

8.5 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.

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.

8.6 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.

8.6.1 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.[178]

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.

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:[179]

> 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

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[178] 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/.

[179] 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.*

poor air quality. The ABCB is currently separately investigating this issue. and changes being proposed to ensure condensation risks were not increased.

Increased fire risk

As discussed in section 8.2, 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.

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.

8.6.2 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.

8.6.3 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 F.6, 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.

8.6.4 Impact on the electricity grid

The estimated impacts of the proposed energy efficiency requirements on the wholesale energy market are discussed in section 6.5. However, there may also be impacts on the electricity grid, particularly at the distribution level.

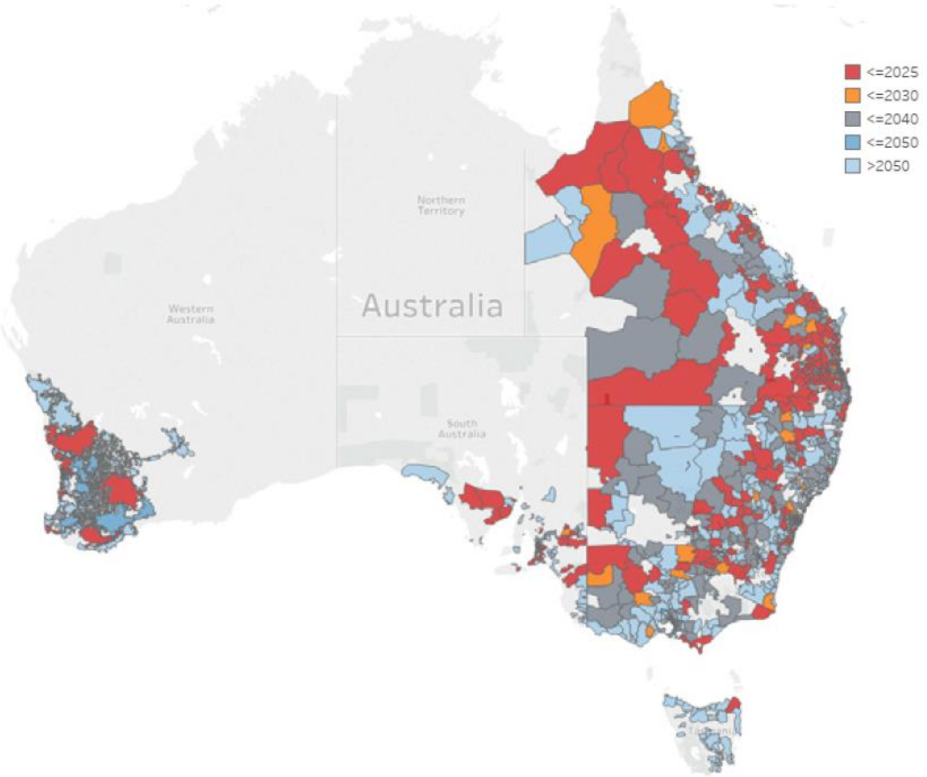
The CSIRO has identified that zone substations can accommodate up to about 40 per cent of their total annual load from solar PV. It has projected, for each postcode in the National Electricity Market and the Western Australian Electricity Market, the decade in which the threshold penetration is exceeded under two different scenarios – a slow Distributed Energy Resources (DER) uptake scenario and a fast DER uptake scenario, see Figure 8.2.

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.

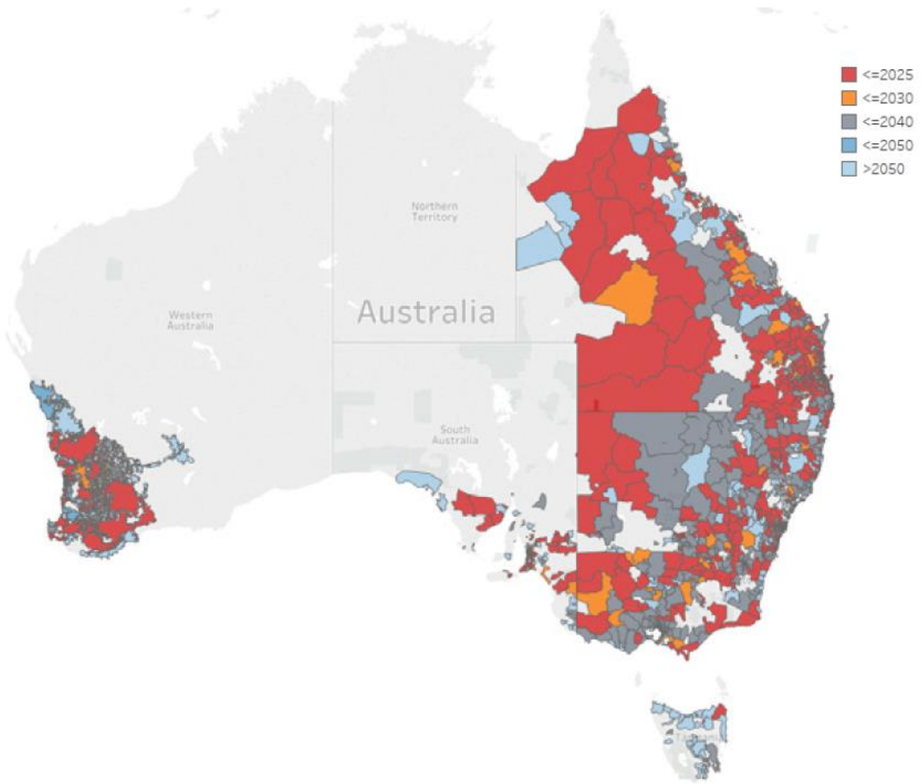
As illustrated in Figure 8.2, the penetration of solar PV systems will exceed the threshold penetration in a number of postcodes by 2025, in particular in regional areas, more so under the fast DER uptake scenario than the slow DER uptake scenario. Stakeholders also identified there is limited capacity for additional solar PV systems in Queensland, South Australia and Victoria (as a result of the Government’s 10 year Solar Homes program).

Figure 8.2 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 F.6, 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 4.5.2, 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.

8.6.5 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 appliances relative to electrical appliances, 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 appliances to be installed as some governments are considering phasing out gas usage[180] and gas appliances are 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 appliances are or are not installed in a new building will depend more on other policy decisions by governments than the requirements in the NCC 2022.

[180] 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.

8.7 Questions for stakeholders

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?
36. Can you provide objective evidence to enable any of the benefits that have not been quantified to be quantified?
37. Are there any other unintended consequences likely to arise from the proposed policy options?
38. Are there any other comments you would like to make in relation to the analysis in the RIS?

Implementation and review 9

9.1 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.[181]

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.

9.2 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.[182] 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:[183]

— 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
— what alternatives to regulation have been considered, and why they are not preferred

[181] Available at https://www.abcb.gov.au/sites/default/files/resources/2020//2020_ABCB_IGA.pdf

[182] 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.

[183] ABCB 2021, *Propose a change page, https://ncc.abcb.gov.au/ncc-online/Propose-a-Change.*

— 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.

10 Conclusion

The analysis of the proposed policy options for more stringent energy efficiency requirements for new dwellings in the NCC 2022 indicates (based on the best available data and assumptions) that there would be a net societal cost for both options – the costs are estimated to outweigh the benefits by a significant margin. The capital costs associated with meeting the proposed energy efficiency requirements are estimated to be well in excess of the societal benefits that are largely derived from avoided resource costs in the energy sector (and which are estimated using wholesale energy costs and avoided network investment as a proxy).

While the analysis varies by option, by class of building and by jurisdiction, it is estimated that there would be a net societal cost for both Class 1 and Class 2 buildings and in each jurisdiction.

- The estimated BCR is higher for Class 1 buildings than for Class 2 buildings under both Option A and Option B.
- The estimated BCR is the highest in the Northern Territory under both policy options and the lowest:
  - under option A, for Class 1 and Class 2 buildings in Western Australia
  - under option B, for Class 1 in Queensland and Class 2 in Western Australia.

The breakeven analysis undertaken indicates that there would need to be a very significant increase in wholesale energy costs (more than three times) and/or a very significant reduction in the capital costs (a discount of around 70 to 80 per cent) for there to be an Australia-wide net societal benefit associated with the proposed policy options.

Even when considered from a household perspective, our analysis indicates that the estimated retail energy savings by the household do not exceed the capital costs associated with the proposed energy efficiency requirements:

- under Option A, for Class 1 buildings in New South Wales, Victoria, Queensland, Tasmania and the ACT and for Class 2 buildings in New South Wales, Victoria, Queensland, South Australia, Western Australia and the Northern Territory
- under Option B, for Class 1 buildings in New South Wales, Victoria, Queensland, Tasmania, Northern Territory and the ACT and for Class 2 buildings in New South Wales, Victoria, Queensland, South Australia, Western Australia and the Northern Territory.

The analysis over the expected life of the regulation using representative buildings and the assumptions outlined in Chapter 4 suggests that the total energy savings as a result of the proposal would be around 174 PJ under Option A and around 114 PJ under Option B, and

15.6 Mt CO_2 (under Option A) and 6.6 Mt CO_2 (under Option B) emissions avoided. However, our assessment suggests that improvements to occupant health and amenity and the resilience of a building to extreme weather and blackouts from the proposal would be immaterial.

Overall, the estimates presented in this RIS point towards the proposed changes to the NCC under both Option A and Option B imposing net costs across Australia (i.e. both options result in a negative economy-wide NPV).

The figures presented above are estimates based on the best information available at the time of the analysis, and assumptions have been used where data was not available. The purpose of this RIS is to seek stakeholder feedback on a number of important questions to inform the ABCB's decision on whether the proposed energy efficiency provisions should be included in the NCC 2022. Some of these questions seek to gain more information that could be used in the Decision RIS to improve the estimates provided above.

References

Access Economics 2008, *Economic Impact of COPD and Cost Effective Solutions*, report prepared for the Australian Lung Foundation.

ACIL Allen Consulting 2018, *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, accessed 16 September 2020.

ACIL Allen Consulting (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.

ACIL Allen Consulting (AAC) 2018, *Power Shift: Healthy and comfortable homes for all Australians*, report to Energy Consumers Australia, September.

AECOM 2020, *Difficult Blocks Final Report,* September.

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.

Alam M, Zou P. X.W., Stewart R. A., Bertone E., Sahin O., Buntine C., Marshall C. 2019, Government championed strategies to overcome the barriers to public building energy efficiency retrofit projects, Sustainable Cities and Society, Volume 44,Pages 56-69, https://sbenrc.com.au/app/uploads/2018/10/P1.43Governmentchampionedstrategies.pdf, accessed 2 February 2021.

Australian Energy Market Commission (AEMC) 2020*, Residential Electricity Price Trends 2020, Final report*, 21 December.

Australian Academy of Technological Sciences and Engineering (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.

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/, accessed 16 September 2020.

Australian Building Codes Board (ABCB) 2019, *Energy Efficiency: NCC 2022 and beyond Outcomes report,* December https://www.abcb.gov.au/Resources/Publications/Consultation/outcomes-report-energy-efficiency-ncc-2022-and-beyond, accessed 16 September 2020.

Australian Building Codes Board (ABCB) 2020, *Building Classifications,* https://www.abcb.gov.au/Resources/Publications/Education-Training/Building-classifications, accessed 16 September 2020.

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.

Australian Bureau of Statistics (ABS) 2021, *Producer Price Indexes, Australia, Cat. No. 6427.0, Table 17. Output of the Construction industries, subdivision and class index numbers*, March.

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, https://www.fwpa.com.au/images/Newsletter_Images/Statistics-count/2018/Dec18/ACI_Structural_framing_materials_used_in_residential_building_Final__3Dec2018.pdf, accessed 17 June 2021.

Australian Energy Market Commission (AEMC) 2021, *Access, pricing and incentive arrangements for distributed energy resources, draft rule determination*, 25 March.

Australian Sustainable Built Environment Council (ASBEC) 2016, *Building Energy Performance Standards Project*, Issues Paper, April.

Australian Sustainable Built Environment Council (ASBEC) 2018, *Built to Perform, an industry led pathway to a zero carbon ready building code*, July, https://www.asbec.asn.au/wordpress/wp-content/uploads/2018/10/180703-ASBEC-CWA-Built-to-Perform-Zero-Carbon-Ready-Building-Code-web.pdf, accessed 28 September 2020.

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.*

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.

Carbon Trust 2011, *Closing the gap: Lessons learned on realizing the potential of low carbon buildings. Carbon Trust*, London.

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.

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

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.

Centre for New Energy Technologies (C4NET) 2021, *Australian Building Codes Board Solar impact investigation*, DRAFT – Victorian residential data analysis, April.

City of Melbourne 2015, *Community Attitudes and Barriers to Rooftop Solar Final report*, August.

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, accessed 21 June 2021.

Commonwealth of Australia, 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.

Commonwealth of Australia, Department of the Prime Minister and Cabinet 2021, *Regulatory Impact Analysis Guide for Ministers' Meetings and National Standard Setting Bodies*, May, https://pmc.gov.au/sites/default/files/publications/regulatory-impact-analysis-guide.pdf, accessed 16 July 2021.

Council of Australian Governments (COAG) 2007, *Best Practice Regulation, A Guide for Ministerial Councils and National Standard Setting Bodies*, October 2007, https://www.pmc.gov.au/sites/default/files/publications/COAG_best_practice_guide_2007.pdf, accessed 17 September 2020.

Council of Australian Governments (COAG) Energy Council 2015, *National Energy Productivity Plan 2015-2030*, http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/National%20Energy%20Productivity%20Plan%20release%20version%20FINAL_0.pdf, accessed 16 September 2020.

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.

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.

Council of Australian Governments (COAG) Energy Council 2020, *Trajectory for Low Energy Buildings Home Page*, http://coagenergycouncil.gov.au/publications/trajectory-low-energy-buildings, accessed 16 September 2020.

Daniel, L., Moore, T., Baker, E., Beer, A., Willand, N., Horne, R. and Hamilton, C. 2020, *Warm, cool and energy affordable housing policy solutions for low-income renters*, AHURI Final Report No. 338, Australian Housing and Urban Research Institute Limited, Melbourne, https://www.ahuri.edu.au/research/final-reports/338, doi: 10.18408/ahuri-3122801.

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.

Deloitte Access Economics (DEA) 2015, *The Hidden Cost of Asthma, report prepared for the Asthma Australia and National Asthma Council of Australia*, November.

Department of the Environment and Energy 2019, *NatHERS assessor handbook*, Canberra.

Department of the Environment and Energy 2019, *Australian Energy Statistics*, September.

Department of Industry, Science, Energy and Resources (DISER) 2020a, *National Greenhouse Accounts Factors, Australian National Greenhouse Accounts*, October, https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2020, accessed 2 March 2021.

Department of Industry, Science, Energy and Resources (DISER) 2020b, *Australia's emissions projections*, December, https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2020, accessed 2 March 2021.

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

Energy Efficiency Strategies (EES) 2021, *Residential Energy Disclosure (RED) Model*, prepared for ACIL Allen.

Energy Efficiency Strategies (EES) 2021, *NCC 2022 Update - Whole of House Component,* Draft Report, May.

Energy Efficient Strategies (EES) Pty Ltd 2020, *NCC 2022 Update – Whole-of-House Component: Draft report*, September.

Energy Efficient Strategies (EES) Pty Ltd 2020, *Whole-of-House DTS Provisions – Draft Modelling Results*, December.

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.*

Energy Networks Australia 2019, *Open Networks Australia, Position Paper.*

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, accessed on 6 August 2021.

Gasparrini, Antonio; Guo, Yuming; Hashizume, Masahiro; Lavigne, Eric; Zanobetti, Antonella; Schwartz, Joel; Tobias, Aurelio; Tong, Shilu; Rocklöv, Joacim; Forsberg, Bertil; Leone, Michela; De Sario, Manuela; Bell, Michelle L; Guo, Yue-Liang Leon; Wu, Chang-fu; Kan, Haidong; Yi, Seung-Muk; de Sousa Zanotti Stagliorio Coelho, Micheline; Saldiva, Paulo Hilario Nascimento; Honda, Yasushi; Kim, Ho; Armstrong, Ben, 2015, *Mortality risk attributable to high and low ambient temperature: a multicountry observational study*, The Lancet, Vol. 386, July, https://core.ac.uk/download/pdf/58763752.pdf, accessed 15 March 2021.

GEER Australia 2017, *Power Shift Project Two Deliverable 1: Overview of Energy Efficiency Co-Benefit*, Group of Energy Efficiency Researchers Australia.

Graham, P., Hayward, J., Foster J. and Havas, L 2021, *GenCost 2020-21: Final report*, Australia, June.

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

Howden-Chapman, Philippa & Matheson, Anna & Crane, Julian & Viggers, Helen & Cunningham, Malcolm & Blakely, Tony & Cunningham, Chris & Woodward, Alistair & Saville-Smith, Kay & O'Dea, Des & Kennedy, Martin & Baker, Michael & Waipara, Nick & Chapman, Ralph & Davie, Gabrielle, 2007, *Effect of insulating existing houses on health inequality: cluster randomised study in the community*, British Medical Journal, doi:10.1136/bmj.39070.573032.80.

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.

International Partnership for Energy Efficiency Cooperation (IPEEC) 2019, *Building Energy Performance Gap Issues: An International Review,* *https://www.energy.gov.au/sites/default/files/the_building_energy_performance_gap-an_international_review-december_2019.pd*, accessed on 6 August 2021.

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.

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

Knauf Insulation 2019, *Simplifying Thermal Bridging Calculation: Improving Energy Efficiency*, https://www.architectureanddesign.com.au/getmedia/643a92bd-2cd0-43d8-a704-5912bf1617ce/Knauf-Whitepaper.aspx?ext=.pdf, accessed 1 September 2020.

Knibbs L.D., Woldeyohannes S., Marks G.B., Cowie C.T. 2018, *Damp housing, gas stoves, and the burden of childhood asthma in Australia*, Medical Journal of Australia, Apr 16;208(7):299-302.

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/, accessed 15 March 2021.

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.

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.

McKinsey & Company 2009, *Unlocking Energy Efficiency in the U.S. Economy*, https://www.sallan.org/pdf-docs/MCKINSEY_US_energy_efficiency.pdf, accessed 27 July 2020.

Moreland Energy Foundation 2017, *Changes Associated with Efficient Dwellings Project – Final Report*, prepared for the Department of the Environment and Energy.

Mudarri, D. and Fisk, W.J. 2007, *Public health and economic impact of dampness and mould*, Indoor Air, 17: 226-235

National Housing Supply Council (NHSC) 2010*, 2nd State of Supply Report*, Canberra, April 2010.

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

O'Leary, Timothy 2016, *Industry adaption to NatHERS 6 star energy regulations and energy performance disclosure models for housing*, December, https://minerva-access.unimelb.edu.au/bitstream/handle/11343/220478/Tim%20Oleary%20final%20with%20corrections.pdf?sequence=1&isAllowed=y, accessed 2 March 2021.

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.

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.

Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Productivity Commission Inquiry Report No.36, 31 August 2005, p. XXXVIII.

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.

Ricke, K., Drouet, L., Caldeira, K. and Tavoni, M. 2018, *Country-level social cost of carbon*, Nature Climate Change 8, 895–900 (2018). https://doi.org/10.1038/s41558-018-0282-y

Scorgie Y, Mazaheri M, Chang L, Ryan L, Fuchs D, Duc H, Monk K and Trieu T 2019, *Air Quality and Public Health Co-benefits of Implementing Energy Efficiency and Clean Energy Measures in New South Wales*, Final Report, report prepared by the NSW Office of Environment and Heritage, February.

SGS Economics & Planning 2021, *Australian Cities Residential Lot Analysis Final Memo*, prepared for the Australian Building Codes Board, January.

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, accessed on 6 August 2021.

Strategy. Policy. Research (SPR) 2017, *Quantifying Commercial Building Learning Rates in Australia: Final Report*, Prepared for the Department of the Environment and Energy, June 2017.

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.

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.

Solar Choice 2020, *Solar for strata & apartment blocks: Everything you need to know (almost)*, https://www.solarchoice.net.au/blog/solar-for-strata-apartment-blocks/, accessed 20 June 2021.

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.

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

Tony Isaacs Consulting (TIC) 2020, *Cost and Benefits of upgrading building fabric from 6 to 7 stars*, September.

Tony Isaacs Consulting (TIC) 2020, *Issues for Class 2 buildings and PV Installation - Proposed solution for the development of NCC 2022 regulations for Class 2*.

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

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

Velux 2020, *Healthy homes barometer 2020,* https://velcdn.azureedge.net/-/media/com/healthy-homes-barometer/hhb-2020/hhb_main_report_2020.pdf, accessed 15 March 2021.

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, accessed on 6 August 2021.

Appendices

Summary of proposed changes to the NCC 2022

A

A.1 Energy efficiency – Summary of changes to Volume Two and Housing Provisions

The proposed changes to the energy efficiency provisions for Class 1 buildings are set out in Table A.1.

As part of the restructure of NCC 2022, energy efficiency DTS elemental provisions in Volume Two are included in the Housing Provisions. Further information about the restructure of NCC 2022 can be found on pages 2 to 6 of the NCC 2022 PCD1 Supporting Information[184].

Table A.1 Summary of proposed energy efficiency changes for Class 1 buildings

NCC Reference	Changes and commentary
Part H6 Energy efficiency H6O1 and H6F1 Objectives and Functional Statements	The Objectives and Functional Statements are expended to reflect the policy intent outlined in the Trajectory. Notably, the Objectives and Functional Statements are explanatory information, that is non-mandatory and informative.
H6P1 Building fabric H6P2 Energy usage	The existing Performance Requirements for Class 1 dwellings in Volume Two, P2.6.1 building fabric and P2.6.2 Services, were quantified to account for the overall stringency increase and the whole-of-home requirements.
H6V2 Verification using a reference building (VURB)	The VURB has been updated to reflect the stringency increase under the proposed DTS elemental provisions. Operating schedules for heating and cooling, thermostat settings, and maximum occupancy are included to provide more clarity for modelling. The Class 1 VURB only covers the building fabric requirements. This is different to the VURB for Class 2 SOUs (Volume One). To satisfy the whole-of-home requirements, DTS elemental provisions, H6P2 or other whole-of-home options can be used.
Specification 42 Using house	Due to the restructure of the NCC undertaken for improved useability, the NatHERS compliance option is in Specification 42 in PCD2.

184 https://consultation.abcb.gov.au/engagement/ncc-2022-public-comment-draft/supporting_documents/NCC%202022%20PCD%20Supporting%20information.pdf

NCC Reference	Changes and commentary
energy rating software	As previously mentioned, the proposed requirements for heating and cooling loads are updated to reflect the one-star stringency increase. Credits for outdoor living areas and ceiling fans are retained with a one-star increase. NatHERS whole-of-home software is included in PCD2 for potential referencing.
Housing provisions (DTS elemental provisions) Part 13.2 Building fabric	Newly proposed insulation requirements have a different structure to the current NCC 2019 provisions. Instead of specifying minimum R-Values to cover all cases, a broad range of building element properties and R-Values (to produce acceptable performance) are presented in a series of look-up tables. This will save practitioners from needing to calculate the Total R-Values themselves.
13.2.3 Roof	Under the new structure of these provisions, minimum R-Values for roof insulation are listed in tables for two types: pitched roof with flat ceiling and flat roof for the 8 NCC climate zones. Minimum R-Values are determined by factors including roof ventilation, reflective insulation, under-roof insulation and solar absorptance in the look-up tables. There is a cap for solar absorptance values in climate zones 1 to 5 at 0.64 for roofs. However, higher solar absorptance values can still be used for cold climates. 13.2.3 requires mitigation of thermal bridging in steel-framed roofs. Several options are available to demonstrate that thermal bridging is mitigated, through either: – meeting a minimum Total R-Value for a flat ceiling below a pitched roof, or – meeting a minimum Total R-Value requirement for the roof in a flat, skillion or cathedral roof, or – adding insulation between ceiling framing elements, adding a thermal break strip over the ceiling framing, or adding a continuous layer of insulation above or below the ceiling framing. The thermal bridging mitigation requirements are in addition to the existing thermal break requirements of Clause 13.2.3(6).
13.2.4 Roof lights	The roof light provisions are updated to align with the changes made to the roof light provisions in NCC 2019 Volume One.
13.2.5 External walls	The proposed wall insulation requirements focus on providing solutions based on the thermal mass of the wall. The wall insulation requirements are based on the dominant construction type for the climate zone: – brick veneer walls in climate zones 2, 4, 5, 6 and 7 – concrete block walls in climate zones 1 and 3; – framed lightweight walls in climate zone 8. Provisions for a second wall type with a different level of thermal mass are also provided. For example, framed lightweight walls are provided in climate zones 1 and 3. Minimum R-Values for different wall types in each climate zone are provided in look-up tables, in consideration of factors including solar absorptance, length of overhangs and wall height.

NCC Reference	Changes and commentary
	There is a cap on solar absorptance values in climate zones 1 to 5 of 0.7 for walls. However, higher solar absorptance values can still be used in cold climates. Allowance for wall height is a new factor proposed for NCC 2022 which affects thermal performance. A higher wall is less shaded by a given overhang than a wall with a lower height. Similar to the thermal bridging requirements for roofs, for walls, thermal bridging requirements for steel-framed dwellings can be met by either achieving total minimum R-Values calculated in accordance with AS/NZS 4859.2 or by applying one of the thermal bridging mitigation options listed in the mitigation options tables. The thermal bridging mitigation requirements are in addition to the existing thermal break requirements of Clause 13.2.5(5).
13.2.6 Floors and subfloor walls	Proposed suspended floor insulation requirements are included in look-up tables showing subfloor wall height, whether reflective foil is installed under the floor and subfloor wall insulation. The most commonly used floor construction in Australia, as shown in CSIRO data, is waffle pod slab floors. It is the dominant floor construction in the cooler climates of Victoria and the ACT. In cooler climates, the use of a waffle pod slab instead of a concrete slab-on-ground will improve the NatHERS rating by around 0.4 stars. Hence, it is proposed to acknowledge the benefits of waffle pod slabs by requiring waffle pods in climate zone 6 to 8 under the DTS elemental provisions. The thermal bridging requirements for steel-framed walls can be met by either achieving total minimum R-Values calculated in accordance with AS/NZS 4859.2 or by applying one of the thermal bridging mitigation options listed in the tables.
Part 13.3 External glazing	The proposed external glazing, in general, uses the same structure and methodology as the current glazing provisions, but is modified to be better aligned with 7-stars NatHERS by introducing a set of new glazing factors: – level factor – bedroom factor – frame factor – hard floor surface factor – window openability. Winter and summer performance of glazing is calculated individually in the current requirements. The proposed new changes clearly separate winter and summer performance requirements. Winter and summer exposure factors are also updated to be better in line with 7-stars NatHERS.
Part 13.5 Ceiling fans	The existing air movement requirements in NCC 2019 are redundant in the new provisions. The air movement requirements are restructured and are included in the proposed changes to the glazing and ceiling fan requirements. Instead of air movement requirements, minimum ceiling fan requirements are proposed for bedrooms and daytime habitable spaces in climate zones 1 to 3, and in daytime habitable spaces in climate zone 5.
Part 13.6 Whole-of-home energy usage	New Part proposed for NCC 2022 which requires the net equivalent energy usage of a building to not exceed a given allowance.

NCC Reference	Changes and commentary
13.6.2 Net equivalent energy usage	Net equivalent energy usage is the overall energy usage of heating, cooling, heated water systems, and swimming pool and spa pumps (if applicable), minus installed capacity of PV. Various combinations of heating, cooling and heated water systems are included in the referenced whole-of-home energy efficiency factors Standard. The whole-of-home energy usage allowance for Class 1 dwellings is based on 70% of the benchmark appliances options (refer introduction). When calculating the net equivalent energy usage and the allowance, floor area adjustment factors account for different size of dwellings to provide a level playing field.

Source: ABCB.

A.2 Energy efficiency - Summary of changes to Volume One

The proposed changes to the energy efficiency provisions in Volume One of the NCC are set out in Table A.2.

Table A.2 Summary of proposed changes for energy efficiency for NCC Volume One 2022

NCC Reference	Changes and commentary
J1P2 (New building fabric of SOUs of a Class 2 building or a Class 4 part) and J1P3 (Energy usage of SOUs of a Class 2 building or a Class 4 part)	These two new quantified Performance Requirements are specific to the SOUs of a Class 2 building or a Class 4 part. They mirror the new quantified Performance Requirements proposed for Class 1 buildings in Volume Two in setting minimum standards for both the envelope of an SOU and the regulated equipment.
J1P4 (New Performance Requirement: Renewable energy and electric vehicle charging)	This new Performance Requirement requires buildings to have features to support the ease of retrofit of PV, EV charging equipment and energy storage equipment. They are supported by a new set of DTS Provisions in Part J9.
J1V1 (formerly JV1 NABERS)	This expands the number of building classifications that can utilise the NABERS methodology to demonstrate compliance with Section J.
J1V2 (formerly JV2 Green Star)	This aligns the NCC with current Green Star modelling methodologies, and reduces conflicts between the Green Star and J1V3 modelling requirements.
J1V5 (New VURB for Class 2 buildings)	A new pathway specifically for Class 2 buildings (both common areas and SOUs). It is based on the VURB pathway J1V3. Its intent is to allow for a single energy model for a Class 2 building to be used to demonstrate compliance.

NCC Reference	Changes and commentary
Specification 34 (formerly JVb Modelling parameters for VURB)	Changes to clarify some modelling parameters used to define the energy use of buildings following the VURB pathway.
Part J3 (New elemental provisions for Class 2 building or a Class 4 part)	These new provisions provide a DTS Provisions for Class 2 SOUs or Class 4 parts of buildings. They are based on alignment with a 7-star NatHERS benchmark for an individual SOU. These provisions align closely to the proposed provisions for Class 1 buildings for envelopes and appliances, with the following key differences: 1. The whole-of-home energy use stringency is set to allow compliance with less (if any) reliance on the use of PV panels. 2. The minimum thermal resistance performance for walls are on the basis of Total R-Value, not added material (bag) R-Value. ***3.*** The only DTS pathway available for floors is for a concrete slab-on-ground.
J4D7 (formerly J1.6 Floors)	Sets the minimum thermal resistance level for floor constructions for the common area of a Class 2 building and Class 3 to 9 buildings. When developing NCC 2019, it was not considered cost beneficial to increase the minimum R-Value requirement from the NCC 2016 level. However, a change the methodology by which thermal resistance was calculated to better account for the impact of soil and sub-floor airspaces, as well as the impact of the building's geometry was recommended. This change introduced an unintended consequence for buildings with a low floor area to perimeter ratio, which would commonly require under slab insulation to comply via the DTS. This is difficult to justify given the reduction in energy costs does not offset the increased cost of the insulation. The exceptions are Class 3, Class 9c or a Class 9a ward area buildings in climate zone 7 and all buildings in climate zone 8, where the addition of insulation was found to be cost-effective.
Part J9 (formerly J8 Energy monitoring and on-site distributed energy resources)	Updates include: 1. Clarifying electricity meters installed in buildings with a floor area greater than 2,500 m^2 for purposes of recording electricity consumption of an SOU are not required to provide sub-metering capability. 2. Expanding where sub-metering is required to include collecting the energy data related to the use of DER such as PV, EV and battery storage systems as part of the broader energy data consumption. 3. Introducing new provisions designed to make retrofit of DER equipment over the life of a building easier. These provisions require space to be left on electrical distribution boards for DER circuit breakers and for cable trays to connect distribution boards to car park spaces in Class 2 buildings. Class 2 buildings will also be required to install charge control devices to ensure EVs will only be charged when there is available electrical capacity in the building. Without this requirement, Class 2 buildings would be required to size their electricity supply to support 100% of car parking spaces being used to charge EV at times of peak demand. This would at least double the required electrical supply capacity for the building.

NCC Reference	Changes and commentary
Specification 36 (formerly J1.2 material properties)	Specification 36 (previously Specification J1.2) provides thermal resistance values (R-Values) for commonly construction materials. It allows NCC users to calculate the thermal resistance of the building fabric when developing a DTS Solution for Part J4. An update is needed to Specification 36 because the airspace R-Values to align with AS/NZ 4859.2 (2018). The existing values in Specification 36 are based on an airgap average temperature of 10°C and temperature difference of 15°C between internal and external conditions. This does not reflect typical Australian conditions. AS/NZ 4859.2 (2018) uses a maximum temperature difference of 10°C. Updating the values by using the current AS/NZS 4859.2 (2018) method will remove the inconsistency between the Specification and Standard. Thermal properties for medium-weight autoclaved aerated concrete were also added.
B1P1 (A new allowance for the addition of PV)	This makes explicit that a notional allowance of 0.15 kPa should be included when designing roof structural systems. This allows for the installation of PV without jeopardising the structural integrity of a roof. Note, this requirement will not mean all roofs will be able to accommodate PV without modification. In some instances, the points of connection between roof sheets and trusses will need to be reinforced as part of the installation of PV panels.
Definition of a "reference building"	The thermal comfort requirement for buildings using the J1V1, J1V2 and J1V3 pathways is set at an absolute level (i.e. it must be ensured "in the proposed building, a thermal comfort level of between a Predicted Mean Vote of -1 to +1 is achieved across not less than 95% of the floor area of all occupied zones for not less than 98% of the annual hours of operation of the building"). However, the definition of a reference building in Schedule 3 reflects that the thermal comfort level of the proposed building need only be better than the reference building in order to comply. This definition creates ambiguity on how to meet the requirement. To reduce this ambiguity, it is proposed the reference to thermal comfort be removed from the definition.

Source: ABCB.

A.2.1 Condensation management

The proposed changes to the condensation management provisions in Volume One of the NCC are set out in Table A.3.

Table A.3 Summary of proposed changes for condensation management in NCC 2022

NCC Reference	Changes and commentary
NCC Volume One F8V1 NCC Volume Two H4V5	This Verification Method provides an optional pathway for demonstrating whether an external wall complies with the condensation requirements. The major changes are: – New references to sections of the standard "AIRAH DA07" to provide further detail on input assumptions for use with the Verification Method. – New failure criteria for the analysis are included: "a mould index of greater than 3, as defined by Section 6 of AIRAH DA07".
NCC Volume One F8D3(2)	Sarking-type materials and secondary insulation layers on the outside of primary insulation in an external wall are required to be vapour permeable in climate zones 4 to 8, where:

NCC Reference	Changes and commentary
ABCB Housing Provisions 10.8.1(2)	– A minimum vapour permeance of 0.143 µg/N.s is specified in climate zones 4 and 5 (equivalent to a Class 3 or Class 4 Vapour Control Membrane as defined by AS 4200.1) – A minimum vapour permeance of 1.14 µg/N.s is specified in climate zones 6, 7 and 8 (equivalent to a Class 4 Vapour Control Membrane as defined by AS 4200.1)
NCC Volume One F6D4(1) ABCB Housing Provisions 10.8.2(1)	Minimum flowrates appropriate for continuously operating exhaust systems have been added.
NCC Volume One F6D4(2) ABCB Housing Provisions 10.8.2(2)	Exhaust from a kitchen, kitchen range hood, bathroom, sanitary compartment or vented clothes dryer is required to be discharged outside of the building.
NCC Volume One F6D4(3) ABCB Housing Provisions 10.8.2(3)	Exhaust systems in bathrooms or sanitary compartments that that are not naturally ventilated (e.g. not provided with windows) are required to be interlocked with the room's light switch and run for at least 10 minutes after the light switch is turned off.
NCC Volume One F6D4(4) ABCB Housing Provisions 10.8.2(4)	To ensure the effective operation of exhaust systems, wet areas with exhaust systems that are not naturally ventilated are required to be provided with make-up air via a door undercut or in accordance with AS 1668.2.
NCC Volume One F6D5 ABCB Housing Provisions 10.8.3	To provide an escape path for water vapour, roofs in climate zones 6, 7 and 8, except those that are subject to Bushfire Attack Level FZ, require a roof space with a height of at least 20 mm and evenly distributed ventilation openings. The required total area of ventilation openings depend on the pitch of the roof and are not required in tiled roofs with a sufficiently permeable sarking (equivalent to a Class 4 Vapour Control Membrane as defined by AS 4200.1).
NCC Volume One J1V4 NCC Volume Two H6V3	This Verification Method provides an optional pathway for demonstrating compliance with the building sealing requirements of the energy efficiency sections of the NCC. The major changes are when a home is found to achieve an air change rate of less than 5 air changes per hour at 50 Pa reference pressure: – Continuous mechanical ventilation is required to be provided to the home. – Solid-fuel and gas combustion appliance are required to be provided with additional ventilation.
Schedule 3	A new defined term for "vapour permeance" is included, referencing the required method of assessing vapour permeance (the ASTM-E96 Water Method at 23 °C), the same test method required by the NCC reference document AS 4200.1.

Source: ABCB.

Overview of ACIL Allen energy market models

B

This Appendix provides an overview of two of our energy market models that were used to provide inputs to our cost benefit analysis:

— PowerMark, which simulates the wholesale electricity market
— GasMark, which simulates the wholesale gas market.

B.1 PowerMark

PowerMark has been developed over the past 20 years in parallel with the development of the National Electricity Market (NEM). PowerMark is a complex model with many unique and valuable features. It provides insights into:

— wholesale pool price trends and volatility
— variability attributable to weather/outages and other stochastic events
— market power and implications for generator bidding behaviour
— network utilisation and generation capacity constraints
— viability of merchant plant and regional interconnections
— contract and price cap values
— timing, size and configuration of new entrant generators
— demands for coal, gas and other fuels; and
— the cost outlook for buyers of wholesale electricity.

PowerMark effectively replicates the Australian Energy Market Operator's (AEMO's) settlement engine — the SPD engine (scheduling, pricing and dispatch). This is achieved through the use of a large-scale linear programming (LP)-based solution incorporating features such as quadratic interconnector loss functions, unit ramp rates, network constraints and dispatchable loads. The veracity of modelled outcomes relative to the AEMO SPD has been extensively tested and exhibits an extremely close fit.

In accordance with the NEM's market design, the price at any one period is the cost of the next increment of generation in each region (the shadow or dual price within the LP). The LP seeks to minimise the aggregate cost of generation for the market as a whole, while meeting regional demand and other network constraints. Figure B.1 is a simplified diagrammatic representation of the model and its methods of combining input data from the supply and demand modules to produce a price and dispatch result for each region and power station for each period.

PowerMark is very flexible. Additional elements, such as regions, interconnectors, generators or loads can be easily added and their characteristics varied through time. PowerMark has been applied to several different market designs — gross pools, net pools, regional and nodal structures.

A distinctive feature of PowerMark is the inclusion of a portfolio optimisation module.[185] This component which is almost always employed when modelling energy-only markets, allows selected portfolios to seek to maximise net revenue positions (taking into consideration contracts for differences) for each period. These modified generator offers are then resubmitted to the settlement engine to determine prices and dispatch levels. Each period is iterated until a convergence point (based on Nash-Cournot / Supply Function equilibrium theory) is found.

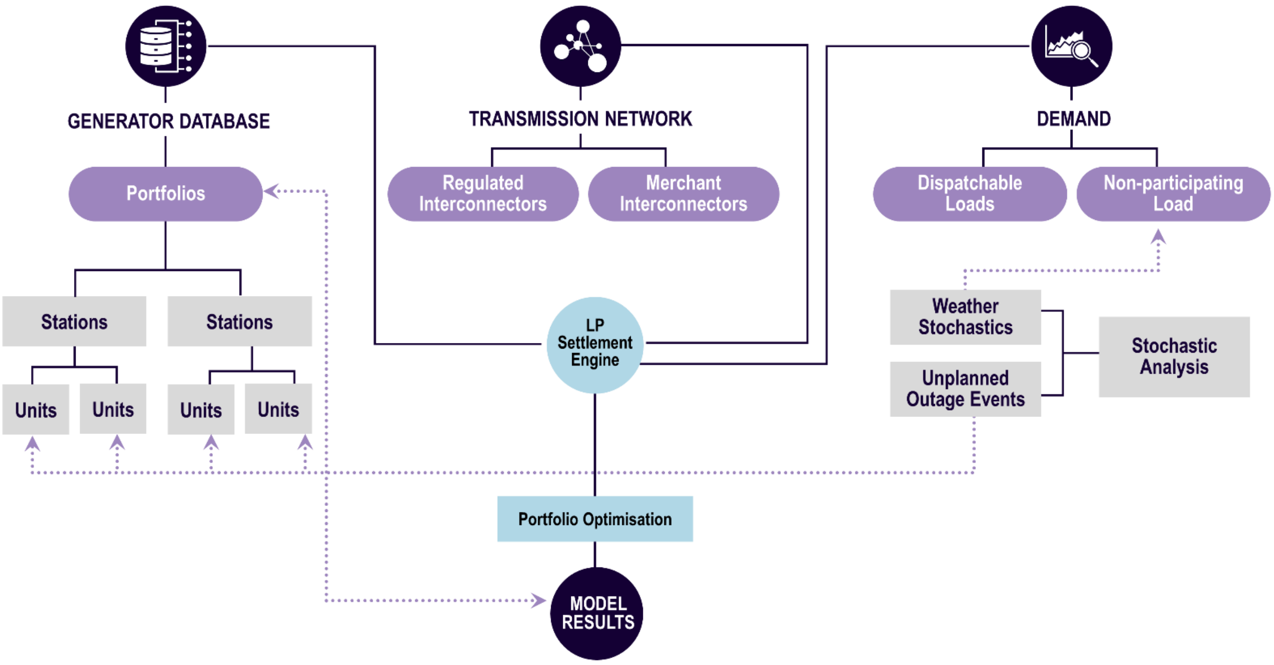
The benefits of the optimisation module are twofold:

— portfolios structure their generation offers in an economically rational way. From past experience, this optimisation process generates strategies which align with the behavioural reality in the marketplace; and
— second-round effects from fundamental changes to the market — such as a policy change, addition or closure of generators, transmission augmentation or creation of additional regions, can automatically be incorporated without imposing explicit constraints or directions for incumbents.

PowerMark can be configured to run at varying time intervals — from 5 minutes (288 period days) through to 180 minutes (8 period days). Typically, the model is run hourly or half-hourly to meet client requirements and establish a reasonable price resolution.

[185] ACIL Allen's energy market models are economic-based models, while AEMO uses a resource-based model for planning and forecasting. As a consequence, the outputs from ACIL Allen's models do not necessarily align with the outputs from AEMO's planning and forecasting models. The outputs from ACIL Allen's models depend on the various inputs and assumptions, which are updated periodically as new information becomes available.

Figure B.1 PowerMark model structure



Source: ACIL Allen

B.2 GasMark

GasMark Global (GMG) is a generic gas modelling platform developed by ACIL Allen. GMG has the flexibility to represent the unique characteristics of gas markets across the globe, including both pipeline gas and LNG. Its potential applications cover a broad scope — from global LNG trade, through to intra-country and regional market analysis. GasMark Global Australia (GMG Australia, or GasMark) is an Australian version of the model which focuses specifically on the Australian market (including both Eastern Australia and Western Australia), but which has the capacity to interface with international LNG markets.

The model can be specified to run at daily, monthly, quarterly or annual resolution over periods up to 30 years.

B.2.1 Settlement

At its core, GasMark is a partial spatial equilibrium model. The market is represented by a collection of spatially related nodal objects (supply sources, demand points, LNG liquefaction and receiving facilities), connected via a network of pipeline or LNG shipping elements (in a similar fashion to ‘arks’ within a network model).

The equilibrium solution of the model is found through application of linear programming techniques which seek to maximise the sum of producer and consumer surplus across the entire market simultaneously. The objective function of this solution, which is well established in economic theory[186], consists of three terms:

- the integral of the demand price function over demand; minus
- the integral of the supply price function over supply; minus
- the sum of the transportation, conversion and storage costs.

The solution results in an economically efficient system where lower cost sources of supply are utilised before more expensive sources and end-users who have higher willingness to pay are served before those who are less willing to pay. Through the process of maximising producer and consumer surplus, transportation costs are minimised and spatial arbitrage opportunities are eliminated. Each market is cleared with a single competitive price.

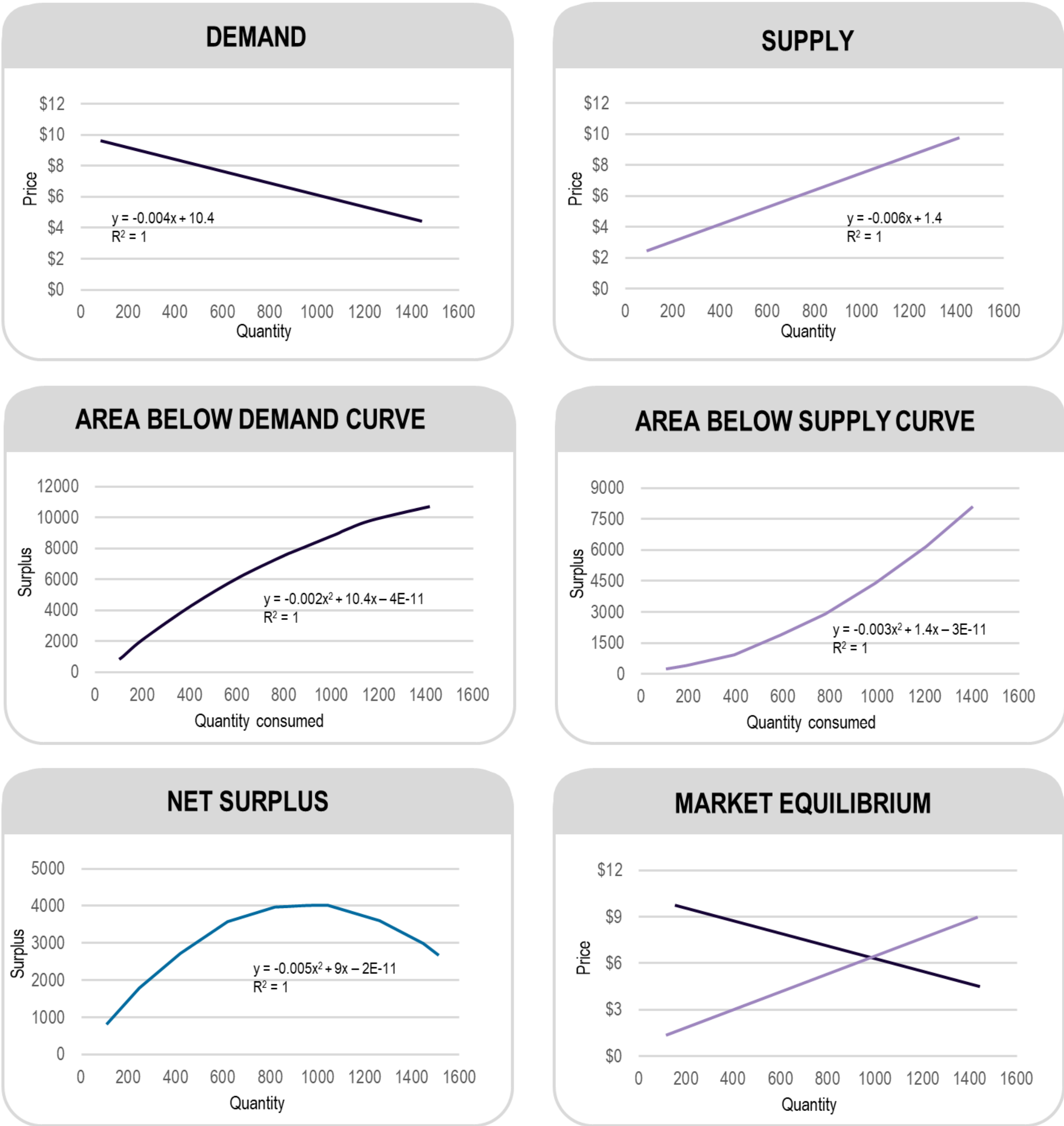
Figure B.2 seeks to explain diagrammatically a simplified example of the optimisation process. The two charts at the top of the figure show simple linear demand and supply functions for a market. The figures in the middle of Figure B.2 show the integrals of these demand and supply functions, which represent the areas under the demand and supply curves. These are equivalent to the consumer and producer surpluses at each price point along the curve. The figure on the bottom left shows the summation of the consumer and producer surplus, with a maximum at a quantity of 900 units. This is equivalent to the equilibrium quantity when demand and supply curves are overlayed as shown in the bottom right figure.

The distinguishing characteristic of spatial price equilibrium models lies in their recognition of the importance of space and transportation costs associated with transporting a commodity from a supply source to a demand centre. Since gas markets are interlinked by a complex series of transportation paths (pipelines, shipping paths) with distinct pricing structures (fixed, zonal or distance based), GMG Australia also includes a detailed network model with these features.

Spatial price equilibrium models have been used to study problems in a number of fields including agriculture, energy markets, mineral economics, as well as in finance. These perfectly competitive partial equilibrium models assume that there are many producers and consumers involved in the production and consumption, respectively, of one or more commodities and that as a result the market settles in an economically efficient fashion. Similar approaches are used within gas market models across the world.

[186] The theoretical framework for the market solution used in GMG is attributed to Nobel Prize winning economist Paul Samuelson.

Figure B.2 Simplified example of market equilibrium and settlement process



Source: ACIL Allen.

B.2.2 Data inputs

The user can establish the level of detail by defining a set of supply regions, customers, demand regions, pipelines and LNG facilities. These sets of basic entities in the model can be very detailed or aggregated as best suits the objectives of the user. A ‘pipeline’ could represent an actual pipeline or a pipeline corridor between a supply and a demand region. A supplier could be a whole gas production basin aggregating the output of many individual fields, or could be a specific producer in a smaller region. Similarly, a demand point could be a single industrial user or an aggregation of small consumers such as the residential and commercial users typically serviced by energy utility companies.

The inputs to GMG Australia can be categorised as follows:

— **Existing and potential new sources of gas supply**: these are characterised by assumptions about available reserves, production rates, production decline characteristics, and minimum price expectations of the producer. These price expectations may be based on long-run marginal costs of production or on market expectations, including producer's understandings of substitute prices.
— **Existing and potential new gas demand**: demand may relate to a specific load such as a power station, or fertiliser plant. Alternatively, it may relate to a group or aggregation of customers, such as the residential or commercial utility load in a particular region or location. Loads are defined in terms of their location, annual and daily gas demand including daily demand profiles, and price tolerance.
— **Existing, new and expanded transmission pipeline capacity**: pipelines are represented in terms of their geographic location, physical capacity (which may vary over time), flow characteristics (uni-directional or bi-directional) and tariffs.
— **Existing, new and expanded gas storage facilities**: Storage is represented in terms of geographic location, physical capacity (which may vary over time), injection and withdrawal rates, storage efficiency and tariffs.
— **Existing and potential new LNG facilities**: LNG facilities include liquefaction plants, regasification (receiving) terminals and assumptions regarding shipping costs and routes. LNG facilities play a similar role to pipelines in that they link supply sources with demand. LNG plants and terminals are defined at the plant level and require assumptions with regard to annual throughput capacity and tariffs for conversion.

Upgrade costs for individual dwellings

C

This Appendix provides details of the estimated marginal costs of compliance with NCC 2022 under each of the upgrade pathways outlined in Chapter 4, for each of the climate zones and jurisdictions modelled by EES. The estimates presented in the tables in this Appendix include:

— all costs incurred at the time of construction, except the additional costs incurred by difficult blocks and the cost of replacement of solar PV inverters after ten years
— the estimated reductions in the costs of space conditioning equipment due to the improved thermal shell (only incurred by dwellings that are 6 stars in the BAU)
— the estimated costs of mitigating thermal bridging in steel frame buildings
— the 10 per cent discount in retail costs discussed in Section 4.4.1 as a proxy to estimate the resource cost of the changes in construction.

C.1 Cost for Class 1 dwellings

This section presents the cost tables for Class 1 dwellings.

Table C.1 Estimated marginal construction costs under Option A — upgrade pathway for Class 1 dwellings with no PV and 6 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	1,045	688	-225	1,176	-145	2,539
NSW	4	1,720	688	-225	1,176	-145	3,214
NSW	5	1,701	688	-225	1,176	-145	3,195
NSW	6	1,529	1,076	-223	1,176	-145	3,413
NSW	7	2,045	957	-246	1,112	-145	3,724
NSW	8	1,380	4,481	-237	65	-145	5,544
VIC	4	1,660	2,448	-219	8	-225	3,671
VIC	6	1,469	2,807	-219	8	-225	3,840
VIC	7	2,014	2,807	-219	8	-225	4,385
VIC	8	1,319	4,970	-220	9	-225	5,853
QLD	1	799	713	-132	1,103	-142	2,341
QLD	2	1,100	160	-141	275	-142	1,252
QLD	3	967	714	-132	1,103	-142	2,509
QLD	5	1,761	736	-132	336	-142	2,558
SA	4	1,705	122	-491	617	-232	1,721
SA	5	1,243	122	-491	617	-232	1,258
SA	6	1,514	779	-491	617	-232	2,186
WA	1	705	507	-509	446	-166	983
WA	3	910	505	-509	446	-166	1,186
WA	4	1,690	201	-496	488	-166	1,718
WA	5	1,055	201	-496	488	-166	1,083
WA	6	1,499	669	-490	492	-166	2,004
TAS	7	1,862	364	109	1,169	-211	3,294
NT	1	1,765	7,860	-127	0	-141	9,356
NT	3	1,596	1,277	-127	0	-141	2,605
ACT	7	1,935	232	-188	769	-236	2,512

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.2 Estimated marginal construction costs under Option B — upgrade pathway for Class 1 dwellings with no PV and 6 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	1,045	649	-226	1,163	-145	2,487
NSW	4	1,720	649	-226	1,163	-145	3,162
NSW	5	1,701	649	-226	1,163	-145	3,143
NSW	6	1,529	681	-226	1,163	-145	3,003
NSW	7	2,045	682	-225	1,164	-145	3,520
NSW	8	1,380	703	-220	1,166	-145	2,884
VIC	4	1,660	66	-189	555	-225	1,867
VIC	6	1,469	97	-181	560	-225	1,720
VIC	7	2,014	66	-181	560	-225	2,235
VIC	8	1,319	610	-174	560	-225	2,091
QLD	1	799	15	-142	29	-142	558
QLD	2	1,100	16	-143	30	-142	861
QLD	3	967	15	-142	29	-142	726
QLD	5	1,761	16	-143	30	-142	1,522
SA	4	1,705	80	-530	477	-232	1,500
SA	5	1,243	78	-521	455	-232	1,023
SA	6	1,514	123	-521	485	-232	1,369
WA	1	705	158	-499	356	-166	554
WA	3	910	158	-499	356	-166	759
WA	4	1,690	186	-496	486	-166	1,701
WA	5	1,055	180	-496	486	-166	1,060
WA	6	1,499	227	-496	486	-166	1,551
TAS	7	1,862	283	-57	323	-211	2,201
NT	1	1,765	35	-127	214	-141	1,745
NT	3	1,596	35	-127	214	-141	1,577
ACT	7	1,935	194	-198	527	-236	2,221

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.3 Estimated marginal construction costs under Option A — upgrade pathway for Class 1 dwellings with no PV and 7 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	191	688	-95	1,176	0	1,960
NSW	4	212	688	-95	1,176	0	1,981
NSW	5	210	688	-95	1,176	0	1,980
NSW	6	210	1,076	-93	1,176	0	2,370
NSW	7	110	957	-115	1,112	0	2,064
NSW	8	N/A	N/A	N/A	N/A	N/A	N/A
VIC	4	151	2,448	-17	8	0	2,590
VIC	6	150	2,807	-17	8	0	2,949
VIC	7	79	2,807	-17	8	0	2,877
VIC	8	N/A	N/A	N/A	N/A	N/A	N/A
QLD	1	283	713	-4	1,103	0	2,096
QLD	2	245	160	-12	275	0	668
QLD	3	172	714	-4	1,103	0	1,985
QLD	5	270	736	-4	336	0	1,339
SA	4	197	122	-283	617	0	653
SA	5	102	122	-283	617	0	559
SA	6	195	779	-283	617	0	1,309
WA	1	189	507	-359	446	0	782
WA	3	114	505	-359	446	0	706
WA	4	182	201	-346	488	0	524
WA	5	95	201	-346	488	0	437
WA	6	180	669	-341	492	0	1,000
TAS	7	0	364	299	1,169	0	1,832
NT	1	801	7,860	0	0	0	8,661
NT	3	801	1,277	0	0	0	2,078
ACT	7	0	232	25	769	0	1,026

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.4 Estimated marginal construction costs under Option B — upgrade pathway for Class 1 dwellings with no PV and 7 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	191	649	**-95**	1,163	0	1,907
NSW	4	212	649	**-95**	1,163	0	1,929
NSW	5	210	649	**-95**	1,163	0	1,927
NSW	6	210	681	**-95**	1,163	0	1,960
NSW	7	110	682	**-95**	1,164	0	1,860
NSW	8	N/A	N/A	N/A	N/A	N/A	N/A
VIC	4	151	66	14	555	0	786
VIC	6	150	97	22	560	0	829
VIC	7	79	66	22	560	0	727
VIC	8	N/A	N/A	N/A	N/A	N/A	N/A
QLD	1	283	15	**-14**	29	0	313
QLD	2	245	16	**-14**	30	0	277
QLD	3	172	15	**-14**	29	0	202
QLD	5	270	16	**-14**	30	0	302
SA	4	197	80	**-321**	477	0	433
SA	5	102	78	**-312**	455	0	323
SA	6	195	123	**-312**	485	0	492
WA	1	189	158	**-350**	356	0	352
WA	3	114	158	**-350**	356	0	278
WA	4	182	186	**-347**	486	0	508
WA	5	95	180	**-347**	486	0	415
WA	6	180	227	**-347**	486	0	547
TAS	7	0	283	133	323	0	739
NT	1	801	35	0	214	0	1,050
NT	3	801	35	0	214	0	1,050
ACT	7	0	194	14	527	0	735

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.5 Estimated marginal construction costs under Option A — upgrade pathway for Class 1 dwellings with 6 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot Water	Plant savings (offset)	Total
NSW	2	855	0	-130	0	-145	580
NSW	4	1,508	0	-130	0	-145	1,233
NSW	5	1,490	0	-130	0	-145	1,215
NSW	6	1,318	0	-130	0	-145	1,043
NSW	7	1,935	0	-130	0	-145	1,660
NSW	8	N/A	N/A	N/A	N/A	N/A	N/A
VIC	4	1,508	0	-202	0	-225	1,081
VIC	6	1,318	0	-202	0	-225	891
VIC	7	1,935	0	-202	0	-225	1,508
VIC	8	1,171	17	-202	0	-225	760
QLD	1	516	0	-128	0	-142	245
QLD	2	855	0	-128	0	-142	584
QLD	3	795	0	-128	0	-142	524
QLD	5	1,490	0	-128	0	-142	1,220
SA	4	1,508	0	-209	0	-232	1,067
SA	5	1,141	0	-209	0	-232	699
SA	6	1,319	1	-209	0	-232	879
WA	1	516	0	-149	0	-166	201
WA	3	795	0	-149	0	-166	481
WA	4	1,508	0	-149	0	-166	1,194
WA	5	960	0	-149	0	-166	646
WA	6	1,341	170	-149	0	-166	1,196
TAS	7	1,862	113	-190	0	-211	1,574
NT	1	964	0	-127	0	-141	695
NT	3	795	0	-127	0	-141	526
ACT	7	1,935	57	-213	0	-236	1,543

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.6 Estimated marginal construction costs under Option B — upgrade pathway for Class 1 dwellings with 6 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	855	0	-130	0	-145	580
NSW	4	1,508	0	-130	0	-145	1,233
NSW	5	1,490	0	-130	0	-145	1,215
NSW	6	1,318	0	-130	0	-145	1,043
NSW	7	1,935	0	-130	0	-145	1,660
NSW	8	N/A	N/A	N/A	N/A	N/A	N/A
VIC	4	1,508	0	-202	0	-225	1,081
VIC	6	1,318	0	-202	0	-225	891
VIC	7	1,935	0	-202	0	-225	1,508
VIC	8	1,168	0	-202	0	-225	741
QLD	1	516	0	-128	0	-142	245
QLD	2	855	0	-128	0	-142	584
QLD	3	795	0	-128	0	-142	524
QLD	5	1,490	0	-128	0	-142	1,220
SA	4	1,508	0	-209	0	-232	1,067
SA	5	1,141	0	-209	0	-232	699
SA	6	1,318	0	-209	0	-232	877
WA	1	516	0	-149	0	-166	201
WA	3	795	0	-149	0	-166	481
WA	4	1,508	0	-149	0	-166	1,194
WA	5	960	0	-149	0	-166	646
WA	6	1,324	8	-149	0	-166	1,017
TAS	7	1,862	29	-190	0	-211	1,490
NT	1	964	0	-127	0	-141	695
NT	3	795	0	-127	0	-141	526
ACT	7	1,935	4	-213	0	-236	1,490

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.7 Estimated marginal construction costs under Option A — upgrade pathway for Class 1 dwellings with 7 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	0	0	0	0	0	0
NSW	4	0	0	0	0	0	0
NSW	5	0	0	0	0	0	0
NSW	6	0	0	0	0	0	0
NSW	7	0	0	0	0	0	0
NSW	8	N/A	N/A	N/A	N/A	N/A	N/A
VIC	4	0	0	0	0	0	0
VIC	6	0	0	0	0	0	0
VIC	7	0	0	0	0	0	0
VIC	8	N/A	N/A	N/A	N/A	N/A	N/A
QLD	1	0	0	0	0	0	0
QLD	2	0	0	0	0	0	0
QLD	3	0	0	0	0	0	0
QLD	5	0	0	0	0	0	0
SA	4	0	0	0	0	0	0
SA	5	0	0	0	0	0	0
SA	6	0	1	0	0	0	1
WA	1	0	0	0	0	0	0
WA	3	0	0	0	0	0	0
WA	4	0	0	0	0	0	0
WA	5	0	0	0	0	0	0
WA	6	23	170	0	0	0	192
TAS	7	0	113	0	0	0	113
NT	1	0	0	0	0	0	0
NT	3	0	0	0	0	0	0
ACT	7	0	57	0	0	0	57

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.8 Estimated marginal construction costs under Option B — upgrade pathway for Class 1 dwellings with 7 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	0	0	0	0	0	0
NSW	4	0	0	0	0	0	0
NSW	5	0	0	0	0	0	0
NSW	6	0	0	0	0	0	0
NSW	7	0	0	0	0	0	0
NSW	8	N/A	N/A	N/A	N/A	N/A	N/A
VIC	4	0	0	0	0	0	0
VIC	6	0	0	0	0	0	0
VIC	7	0	0	0	0	0	0
VIC	8	N/A	N/A	N/A	N/A	N/A	N/A
QLD	1	0	0	0	0	0	0
QLD	2	0	0	0	0	0	0
QLD	3	0	0	0	0	0	0
QLD	5	0	0	0	0	0	0
SA	4	0	0	0	0	0	0
SA	5	0	0	0	0	0	0
SA	6	0	0	0	0	0	0
WA	1	0	0	0	0	0	0
WA	3	0	0	0	0	0	0
WA	4	0	0	0	0	0	0
WA	5	0	0	0	0	0	0
WA	6	5	8	0	0	0	13
TAS	7	0	29	0	0	0	29
NT	1	0	0	0	0	0	0
NT	3	0	0	0	0	0	0
ACT	7	0	4	0	0	0	4

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.9 Estimated marginal construction costs under Option A — upgrade pathway for Class 1 dwellings with 6 stars and with a pool or spa installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	1,045	0	0	0	-145	901
NSW	4	1,720	4,427	0	0	-145	6,002
NSW	5	1,701	4,427	0	0	-145	5,983
NSW	6	1,529	4,427	0	0	-145	5,811
NSW	7	2,045	4,427	0	0	-145	6,328
NSW	8	1,380	4,427	0	0	-145	5,662
VIC	4	1,660	4,842	0	0	-225	6,277
VIC	6	1,469	4,842	0	0	-225	6,086
VIC	7	2,014	4,842	0	0	-225	6,631
VIC	8	1,319	4,842	0	0	-225	5,937
QLD	1	799	0	0	0	-142	657
QLD	2	1,100	0	0	0	-142	957
QLD	3	967	0	0	0	-142	824
QLD	5	1,761	0	0	0	-142	1,618
SA	4	1,705	5,109	0	0	-232	6,582
SA	5	1,243	5,109	0	0	-232	6,120
SA	6	1,514	5,109	0	0	-232	6,390
WA	1	705	3,957	0	0	-166	4,497
WA	3	910	3,957	0	0	-166	4,701
WA	4	1,690	0	0	0	-166	1,524
WA	5	1,055	0	0	0	-166	889
WA	6	1,499	0	0	0	-166	1,333
TAS	7	1,862	0	0	0	-211	1,651
NT	1	1,765	7,899	0	0	-141	9,522
NT	3	1,596	7,899	0	0	-141	9,354
ACT	7	1,935	0	0	0	-236	1,699

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table C.10 Estimated marginal construction costs under Option B — upgrade pathway for Class 1 dwellings with 6 stars and with a pool or spa installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), $/dwelling

Jurisdiction	NCC climate	Shell	Solar PV[a]	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	1,045	0	0	0	**-145**	901
NSW	4	1,720	0	0	0	**-145**	1,575
NSW	5	1,701	0	0	0	**-145**	1,556
NSW	6	1,529	0	0	0	**-145**	1,384
NSW	7	2,045	0	0	0	**-145**	1,901
NSW	8	1,380	0	0	0	**-145**	1,235
VIC	4	1,660	0	0	0	**-225**	1,435
VIC	6	1,469	0	0	0	**-225**	1,244
VIC	7	2,014	0	0	0	**-225**	1,789
VIC	8	1,319	4,842	0	0	**-225**	5,937
QLD	1	799	0	0	0	**-142**	657
QLD	2	1,100	0	0	0	**-142**	957
QLD	3	967	0	0	0	**-142**	824
QLD	5	1,761	0	0	0	**-142**	1,618
SA	4	1,705	0	0	0	**-232**	1,473
SA	5	1,243	0	0	0	**-232**	1,011
SA	6	1,514	0	0	0	**-232**	1,282
WA	1	705	0	0	0	**-166**	539
WA	3	910	0	0	0	**-166**	744
WA	4	1,690	0	0	0	**-166**	1,524
WA	5	1,055	0	0	0	**-166**	889
WA	6	1,499	0	0	0	**-166**	1,333
TAS	7	1,862	0	0	0	**-211**	1,651
NT	1	1,765	7,899	0	0	**-141**	9,522
NT	3	1,596	0	0	0	**-141**	1,455
ACT	7	1,935	0	0	0	**-236**	1,699

[a] Includes the cost of solar panels and inverter (for the first year only). As noted in Chapter 4, inverters are assumed to be replaced in year 11, the cost of this second inverter is not included in this table.

Note: Negative numbers reflect savings in construction costs. Plant savings offsets only applicable to buildings that are 6 stars in the BAU. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

C.2 Cost for Class 2 dwellings

This section presents the cost tables for Class 2 dwellings.

Table C.11 Estimated marginal construction costs under Option A — upgrade pathway for Class 2 dwellings with 6 stars in the BAU (all equipment upgrade pathway), $/dwelling

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	582	263	1,869	-112	2,602
NSW	4	360	263	1,869	-112	2,380
NSW	5	704	263	1,869	-112	2,723
NSW	6	502	264	1,869	-112	2,522
NSW	7	1,057	263	1,869	-112	3,077
VIC	6	501	1,794	1,739	-139	3,894
VIC	7	1,056	1,786	1,742	-139	4,444
QLD	1	274	1,349	1,725	-83	3,265
QLD	2	581	1,349	1,725	-83	3,572
QLD	5	702	1,349	1,725	-83	3,693
SA	5	718	85	1,842	-125	2,520
WA	5	495	589	1,849	-92	2,842
TAS	7	423	-81	1,925	-118	2,149
NT	1	421	2,677	1,193	-103	4,189
ACT	7	1,062	-91	1,743	-135	2,579

Note: Negative numbers reflect savings in construction costs. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

Table C.12 Estimated marginal construction costs under Option B — upgrade pathway for Class 2 dwellings with 6 stars in the BAU (all equipment upgrade pathway), $/dwelling

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	582	213	1,613	-101	2,308
NSW	4	360	213	1,613	-101	2,086
NSW	5	704	213	1,613	-101	2,429
NSW	6	502	213	1,613	-101	2,228
NSW	7	1,057	213	1,613	-101	2,783
VIC	6	501	-51	1,743	-125	2,068
VIC	7	1,056	-51	1,743	-125	2,623
QLD	1	274	-23	64	-74	240
QLD	2	581	-24	65	-74	548
QLD	5	702	-24	65	-74	669
SA	5	718	85	1,842	-112	2,532
WA	5	495	574	1,842	-82	2,828
TAS	7	423	-92	1,522	-106	1,746
NT	1	421	222	1,561	-92	2,112
ACT	7	1,062	-99	1,446	-121	2,288

Note: Negative numbers reflect savings in construction costs. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

Table C.13 Estimated marginal construction costs under Option A — upgrade pathway for Class 2 dwellings with 7 stars in the BAU (all equipment upgrade pathway), $/dwelling

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	3	365	1,869	0	2,236
NSW	4	4	365	1,869	0	2,237
NSW	5	4	365	1,869	0	2,238
NSW	6	3	366	1,869	0	2,238
NSW	7	4	365	1,869	0	2,238
VIC	6	2	1,920	1,739	0	3,661
VIC	7	3	1,911	1,742	0	3,656
QLD	1	2	1,423	1,725	0	3,150
QLD	2	2	1,423	1,725	0	3,150
QLD	5	3	1,423	1,725	0	3,151
SA	5	8	197	1,842	0	2,047
WA	5	42	671	1,849	0	2,563
TAS	7	1	26	1,925	0	1,952
NT	1	8	2,769	1,193	0	3,970
ACT	7	9	31	1,743	0	1,782

Note: Negative numbers reflect savings in construction costs. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

Table C.14 Estimated marginal construction costs under Option B — upgrade pathway for Class 2 dwellings with 7 stars in the BAU (all equipment upgrade pathway), $/dwelling

Jurisdiction	NCC climate	Shell	Heating and cooling	Hot water	Plant savings (offset)	Total
NSW	2	3	315	1,613	0	1,931
NSW	4	4	315	1,613	0	1,932
NSW	5	4	315	1,613	0	1,932
NSW	6	3	315	1,613	0	1,931
NSW	7	4	315	1,613	0	1,932
VIC	6	2	74	1,743	0	1,820
VIC	7	3	74	1,743	0	1,821
QLD	1	2	51	64	0	117
QLD	2	2	51	65	0	117
QLD	5	3	51	65	0	118
SA	5	8	197	1,842	0	2,047
WA	5	42	657	1,842	0	2,540
TAS	7	1	14	1,522	0	1,537
NT	1	8	315	1,561	0	1,883
ACT	7	9	22	1,446	0	1,477

Note: Negative numbers reflect savings in construction costs. Totals may not add up due to rounding.
Source: ACIL Allen based on EES data.

Changes in energy consumption for individual dwellings

D

This Appendix provides details of the estimated changes in energy consumption associated with the NCC 2022 under each upgrade pathways outlined in Chapter 4 for each of the climate zones and jurisdictions modelled by EES.

D.1 Class 1 dwellings

This section presents the energy flows tables for Class 1 dwellings.

Table D.1 Estimated changes in energy consumption under Option A — upgrade pathway for Class 1 dwellings with no PV and 6 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), 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	800	-7,052	-17	-6,269	1,910	2,874	-85,545	-523	-83,194	38,195
NSW	4	386	-7,780	-121	-7,515	1,811	-10,901	-97,823	-3,623	-112,347	36,215
NSW	5	722	-7,641	-69	-6,988	1,561	-960	-94,874	-2,064	-97,898	31,211
NSW	6	321	-8,322	-267	-8,268	2,134	-11,275	-108,788	-7,996	-128,058	42,683
NSW	7	72	-8,079	-128	-8,135	2,276	-17,464	-105,773	-3,831	-127,068	45,511
NSW	8	-5,030	-1,783	-237	-7,050	9,592	-114,319	-44,914	-7,115	-166,349	191,842
VIC	4	-3,539	-211	-129	-3,879	5,202	-82,053	-5,378	-3,885	-91,315	104,036
VIC	6	-3,385	-417	-304	-4,106	4,768	-75,012	-11,498	-9,122	-95,633	95,360
VIC	7	-4,217	-382	-270	-4,868	5,182	-99,065	-10,423	-8,094	-117,582	103,637
VIC	8	-5,718	-723	-501	-6,942	9,619	-132,544	-20,471	-15,032	-168,047	192,372
QLD	1	-4,073	-183	-0	-4,256	1,632	-64,589	-2,202	-2	-66,793	32,643
QLD	2	-969	-191	-5	-1,166	288	-14,980	-2,408	-155	-17,544	5,760
QLD	3	-4,414	-190	-18	-4,621	1,874	-72,847	-2,393	-534	-75,774	37,477
QLD	5	-1,818	-219	-46	-2,083	1,431	-31,915	-3,019	-1,379	-36,312	28,615
SA	4	-426	-3,814	-364	-4,605	277	-14,110	-62,072	-10,930	-87,112	5,549
SA	5	-365	-3,569	-214	-4,149	254	-12,263	-54,725	-6,425	-73,413	5,081
SA	6	-711	-4,846	-780	-6,337	1,259	-16,891	-90,936	-23,391	-131,218	25,184
WA	1	-1,049	-2,028	-0	-3,077	1,286	-26,732	-24,346	-4	-51,082	25,729
WA	3	-1,276	-2,238	-26	-3,541	1,480	-32,906	-30,580	-786	-64,272	29,597

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	-441	-3,482	-122	-4,046	521	-13,528	-60,471	-3,669	-77,668	10,417
WA	5	-201	-3,180	-68	-3,449	531	-6,279	-54,086	-2,050	-62,415	10,616
WA	6	-564	-4,709	-294	-5,567	1,472	-13,466	-95,023	-8,824	-117,312	29,440
TAS	7	-3,257	-2,006	-3,483	-8,746	550	-41,804	-36,100	-104,488	-182,392	11,008
NT	1	-8,231	0	0	-8,231	9,274	-204,513	0	0	-204,513	185,478
NT	3	-2,199	0	-3	-2,202	1,643	-54,046	0	-84	-54,129	32,858
ACT	7	-1,759	-3,262	-261	-5,282	602	-34,935	-55,763	-7,818	-98,515	12,043

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 4. 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 D.2 Estimated changes in energy consumption under Option B — upgrade pathway for Class 1 dwellings with no PV and 6 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), 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	872	-7,051	-17	-6,197	1,803	4,021	-85,533	-518	-82,030	36,063
NSW	4	464	-7,780	-120	-7,436	1,709	-9,627	-97,823	-3,603	-111,053	34,190
NSW	5	797	-7,641	-68	-6,912	1,473	247	-94,874	-2,048	-96,674	29,459
NSW	6	820	-8,322	-252	-7,754	1,435	-1,980	-108,788	-7,560	-118,327	28,691

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	600	-8,572	-266	-8,237	1,683	-7,090	-112,594	-7,967	-127,652	33,656
NSW	8	764	-9,714	-592	-9,542	1,585	-5,503	-140,092	-17,764	-163,358	31,700
VIC	4	-953	-2,483	-179	-3,614	155	-25,107	-34,569	-5,371	-65,047	3,105
VIC	6	-737	-2,902	-437	-4,076	174	-18,886	-44,884	-13,103	-76,873	3,483
VIC	7	-934	-2,978	-437	-4,349	143	-24,182	-46,064	-13,115	-83,360	2,858
VIC	8	-1,486	-3,791	-1,053	-6,329	1,195	-36,429	-68,250	-31,589	-136,268	23,899
QLD	1	-620	-173	-0	-793	36	-19,185	-2,071	-2	-21,257	725
QLD	2	-109	-191	-4	-304	40	-3,894	-2,408	-107	-6,409	792
QLD	3	-852	-180	-11	-1,042	42	-26,092	-2,259	-318	-28,669	840
QLD	5	-290	-219	-16	-525	33	-9,365	-3,019	-473	-12,856	663
SA	4	-96	-3,702	-231	-4,029	182	-10,742	-60,729	-6,920	-78,392	3,635
SA	5	91	-3,513	-140	-3,563	161	-7,039	-54,054	-4,207	-65,300	3,220
SA	6	251	-4,788	-605	-5,142	221	-1,227	-90,239	-18,146	-109,613	4,424
WA	1	-314	-2,061	-0	-2,375	411	-14,424	-24,745	-4	-39,173	8,227
WA	3	-523	-2,268	-26	-2,817	477	-20,193	-30,854	-786	-51,834	9,542
WA	4	-421	-3,482	-121	-4,024	477	-13,168	-60,471	-3,627	-77,266	9,548
WA	5	-171	-3,180	-67	-3,418	473	-5,766	-54,086	-2,009	-61,861	9,466
WA	6	-105	-4,675	-277	-5,057	464	-4,174	-94,421	-8,319	-106,914	9,288
TAS	7	-783	-1,991	-2,186	-4,961	372	-16,619	-35,927	-65,586	-118,132	7,443
NT	1	-1,932	-103	0	-2,035	43	-50,348	-1,234	0	-51,582	861

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
NT	3	**-1,571**	**-123**	**-3**	**-1,697**	46	-37,999	-1,475	-91	-39,565	915
ACT	7	**-970**	**-3,257**	**-173**	**-4,399**	479	-25,685	-55,710	-5,177	-86,572	9,589

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 4. 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 D.3 Estimated changes in energy consumption under Option A — upgrade pathway for Class 1 dwellings with no PV and 7 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
NSW	2	940	**-7,053**	**-13**	**-6,126**	1,910	7,065	**-85,590**	**-379**	**-78,904**	38,195
NSW	4	1,041	**-7,781**	**-59**	**-6,800**	1,811	8,761	**-97,863**	**-1,785**	**-90,887**	36,215
NSW	5	1,048	**-7,663**	**-48**	**-6,663**	1,561	8,819	**-95,546**	**-1,427**	**-88,154**	31,211
NSW	6	835	**-8,283**	**-123**	**-7,571**	2,134	4,152	**-107,633**	**-3,678**	**-107,160**	42,683
NSW	7	734	**-8,116**	0	**-7,382**	2,276	2,396	**-106,882**	0	**-104,485**	45,511
NSW	8	0	**0**	0	0	0	0	**0**	0	0	0
VIC	4	**-2,749**	**-106**	0	**-2,855**	5,202	**-58,361**	**-2,223**	0	**-60,584**	104,036
VIC	6	**-2,773**	**-148**	0	**-2,921**	4,768	**-56,657**	**-3,434**	0	**-60,091**	95,360
VIC	7	**-3,406**	**-180**	0	**-3,587**	5,182	**-74,743**	**-4,388**	0	**-79,131**	103,637

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
VIC	8	0	0	0	0	0	0	0	0	0	0
QLD	1	**-3,422**	**-183**	**-0**	**-3,606**	1,632	**-45,080**	**-2,201**	**-0**	**-47,281**	32,643
QLD	2	**-828**	**-191**	**-2**	**-1,022**	288	**-10,750**	**-2,416**	**-53**	**-13,219**	5,760
QLD	3	**-3,533**	**-190**	**-7**	**-3,730**	1,874	**-46,437**	**-2,384**	**-217**	**-49,037**	37,477
QLD	5	**-1,491**	**-222**	**-31**	**-1,744**	1,431	**-22,108**	**-3,121**	**-926**	**-26,155**	28,615
SA	4	280	**-3,797**	**-149**	**-3,666**	277	7,075	**-61,567**	**-4,455**	**-58,947**	5,549
SA	5	235	**-3,591**	**-115**	**-3,471**	254	5,743	**-55,375**	**-3,463**	**-53,095**	5,081
SA	6	**-204**	**-4,649**	**-273**	**-5,126**	1,259	**-1,687**	**-85,018**	**-8,187**	**-94,892**	25,184
WA	1	**-427**	**-2,027**	0	**-2,454**	1,286	**-8,078**	**-24,329**	0	**-32,407**	25,729
WA	3	**-462**	**-2,221**	0	**-2,683**	1,480	**-8,484**	**-30,048**	0	**-38,532**	29,597
WA	4	127	**-3,500**	**-14**	**-3,387**	521	3,527	**-60,997**	**-432**	**-57,902**	10,417
WA	5	130	**-3,261**	**-14**	**-3,145**	531	3,659	**-56,533**	**-416**	**-53,291**	10,616
WA	6	**-193**	**-4,486**	**-41**	**-4,719**	1,472	**-2,343**	**-88,310**	**-1,222**	**-91,876**	29,440
TAS	7	**-2,591**	**-1,940**	**-2,440**	**-6,971**	550	**-21,820**	**-34,128**	**-73,187**	**-129,135**	11,008
NT	1	**-6,729**	0	0	**-6,729**	9,274	**-159,437**	0	0	**-159,437**	185,478
NT	3	**-1,142**	0	0	**-1,142**	1,643	**-22,330**	0	0	**-22,330**	32,858
ACT	7	**-897**	**-3,040**	**-148**	**-4,085**	602	**-9,060**	**-49,106**	**-4,445**	**-62,611**	12,043

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table D.4 Estimated changes in energy consumption under Option B — upgrade pathway for Class 1 dwellings with no PV and 7 stars in the BAU (lowest cost upgrade pathway of two alternative response options analysed), 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	1,011	-7,053	-12	-6,054	1,803	8,212	-85,578	-375	-77,740	36,063
NSW	4	1,119	-7,781	-59	-6,721	1,709	10,035	-97,863	-1,764	-89,593	34,190
NSW	5	1,123	-7,663	-47	-6,588	1,473	10,026	-95,546	-1,411	-86,931	29,459
NSW	6	1,334	-8,283	-108	-7,057	1,435	13,447	-107,633	-3,242	-97,429	28,691
NSW	7	1,262	-8,609	-138	-7,485	1,683	12,770	-113,703	-4,136	-105,069	33,656
NSW	8	0	0	0	0	0	0	0	0	0	0
VIC	4	-163	-2,377	-50	-2,590	155	-1,415	-31,415	-1,486	-34,317	3,105
VIC	6	-125	-2,633	-133	-2,891	174	-532	-36,820	-3,980	-41,331	3,483
VIC	7	-123	-2,777	-167	-3,067	143	141	-40,029	-5,020	-44,909	2,858
VIC	8	0	0	0	0	0	0	0	0	0	0
QLD	1	30	-173	-0	-142	36	324	-2,070	-0	-1,746	725
QLD	2	32	-191	-0	-160	40	337	-2,416	-5	-2,084	792
QLD	3	29	-180	-0	-151	42	318	-2,249	-1	-1,932	840
QLD	5	37	-222	-1	-186	33	443	-3,121	-20	-2,699	663
SA	4	610	-3,686	-15	-3,091	182	10,443	-60,225	-446	-50,227	3,635
SA	5	691	-3,535	-41	-2,885	161	10,967	-54,704	-1,244	-44,981	3,220
SA	6	758	-4,591	-98	-3,931	221	13,976	-84,321	-2,942	-73,286	4,424

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	1	308	**-2,061**	0	**-1,753**	411	4,231	**-24,728**	0	**-20,498**	8,227
WA	3	291	**-2,250**	0	**-1,959**	477	4,228	**-30,322**	0	**-26,093**	9,542
WA	4	147	**-3,500**	**-13**	**-3,366**	477	3,888	**-60,997**	**-390**	**-57,500**	9,548
WA	5	160	**-3,261**	**-13**	**-3,114**	473	4,172	**-56,533**	**-376**	**-52,737**	9,466
WA	6	266	**-4,451**	**-24**	**-4,209**	464	6,948	**-87,709**	**-717**	**-81,477**	9,288
TAS	7	**-117**	**-1,926**	**-1,143**	**-3,186**	372	3,365	**-33,956**	**-34,285**	**-64,875**	7,443
NT	1	**-430**	**-103**	0	**-533**	43	**-5,271**	**-1,234**	0	**-6,505**	861
NT	3	**-514**	**-123**	**-0**	**-637**	46	**-6,283**	**-1,475**	**-8**	**-7,766**	915
ACT	7	**-107**	**-3,035**	**-60**	**-3,202**	479	190	**-49,053**	**-1,804**	**-50,667**	9,589

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table D.5 Estimated changes in energy consumption under Option A — upgrade pathway for Class 1 dwellings with 6 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), 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	-46	-4	-5	-56	104	-1,311	-129	-144	-1,584	2,073
NSW	4	-367	-57	-61	-486	320	-10,650	-1,712	-1,839	-14,200	6,398
NSW	5	-127	-18	-21	-166	221	-3,735	-541	-637	-4,913	4,419
NSW	6	-452	-134	-144	-730	69	-13,300	-4,015	-4,318	-21,633	1,389
NSW	7	-444	-101	-128	-673	243	-12,950	-3,035	-3,831	-19,815	4,856
NSW	8	0	0	0	0	0	0	0	0	0	0
VIC	4	-446	-136	-129	-712	382	-12,942	-4,076	-3,885	-20,903	7,634
VIC	6	-543	-319	-304	-1,166	76	-15,968	-9,569	-9,122	-34,659	1,525
VIC	7	-552	-274	-270	-1,095	288	-16,075	-8,213	-8,094	-32,382	5,759
VIC	8	-938	-513	-501	-1,952	217	-27,568	-15,388	-15,032	-57,989	4,335
QLD	1	-222	-0	-0	-222	476	-6,380	-0	-2	-6,382	9,529
QLD	2	-52	-1	-3	-56	99	-1,431	-17	-102	-1,550	1,976
QLD	3	-582	-2	-11	-595	332	-17,050	-65	-317	-17,432	6,632
QLD	5	-132	-2	-15	-149	217	-3,859	-72	-453	-4,384	4,335
SA	4	-396	-238	-216	-849	345	-11,410	-7,139	-6,475	-25,024	6,901
SA	5	-268	-109	-99	-476	369	-7,704	-3,268	-2,962	-13,935	7,377
SA	6	-462	-558	-507	-1,527	55	-13,502	-16,748	-15,204	-45,454	1,100
WA	1	-213	-1	-0	-213	455	-6,171	-17	-4	-6,192	9,092
WA	3	-529	-99	-26	-654	317	-15,536	-2,965	-786	-19,287	6,331

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
WA	4	-306	-354	-108	-768	291	-8,804	-10,614	-3,237	-22,656	5,827
WA	5	-169	-164	-54	-388	180	-4,845	-4,919	-1,634	-11,397	3,604
WA	6	-354	-830	-253	-1,437	715	-10,232	-24,900	-7,602	-42,734	14,307
TAS	7	-598	-153	-1,043	-1,795	414	-17,338	-4,599	-31,301	-53,238	8,283
NT	1	-642	0	0	-642	956	-18,734	0	0	-18,734	19,127
NT	3	-691	0	-3	-693	407	-20,282	0	-84	-20,365	8,147
ACT	7	-615	-280	-112	-1,008	539	-17,736	-8,400	-3,373	-29,508	10,775

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table D.6 Estimated changes in energy consumption under Option B — upgrade pathway for Class 1 dwellings with 6 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
NSW	2	-46	-4	-5	-56	104	-1,311	-129	-144	-1,584	2,073
NSW	4	-367	-57	-61	-486	320	-10,650	-1,712	-1,839	-14,200	6,398
NSW	5	-127	-18	-21	-166	221	-3,735	-541	-637	-4,913	4,419
NSW	6	-452	-134	-144	-730	69	-13,300	-4,015	-4,318	-21,633	1,386

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
NSW	7	-444	-101	-128	-673	242	-12,950	-3,035	-3,831	-19,815	4,843
NSW	8	0	0	0	0	0	0	0	0	0	0
VIC	4	-446	-136	-129	-712	382	-12,942	-4,076	-3,885	-20,903	7,634
VIC	6	-543	-319	-304	-1,166	76	-15,968	-9,569	-9,122	-34,659	1,525
VIC	7	-552	-274	-270	-1,095	288	-16,075	-8,213	-8,094	-32,382	5,759
VIC	8	-936	-513	-501	-1,950	140	-27,537	-15,388	-15,032	-57,957	2,807
QLD	1	-222	-0	-0	-222	476	-6,380	-0	-2	-6,382	9,529
QLD	2	-52	-1	-3	-56	99	-1,431	-17	-102	-1,550	1,976
QLD	3	-582	-2	-11	-595	332	-17,050	-65	-317	-17,432	6,632
QLD	5	-132	-2	-15	-149	217	-3,859	-72	-453	-4,384	4,335
SA	4	-396	-238	-216	-849	345	-11,410	-7,139	-6,475	-25,024	6,901
SA	5	-268	-109	-99	-476	369	-7,704	-3,268	-2,962	-13,935	7,377
SA	6	-462	-558	-507	-1,527	50	-13,499	-16,748	-15,204	-45,452	1,002
WA	1	-213	-1	-0	-213	455	-6,171	-17	-4	-6,192	9,092
WA	3	-529	-99	-26	-654	317	-15,536	-2,965	-786	-19,287	6,331
WA	4	-306	-354	-108	-768	291	-8,804	-10,614	-3,237	-22,656	5,827
WA	5	-169	-164	-54	-388	180	-4,845	-4,919	-1,634	-11,397	3,604
WA	6	-342	-830	-253	-1,425	67	-9,973	-24,900	-7,602	-42,475	1,344
TAS	7	-594	-153	-1,043	-1,791	165	-17,261	-4,599	-31,301	-53,161	3,295
NT	1	-642	0	0	-642	956	-18,734	0	0	-18,734	19,127

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	
NT	3	-691	0	-3	-693	407	-20,282	0	-84	-20,365	8,147
ACT	7	-613	-280	-112	-1,005	294	-17,673	-8,400	-3,373	-29,446	5,889

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest. Totals may not add up due to rounding.

Source: ACIL Allen based on EES data.

Table D.7 Estimated changes in energy consumption under Option A — upgrade pathway for Class 1 dwellings with 7 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), 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	0	0	0	0	0	0	0	0	0	0
NSW	4	0	0	0	0	0	0	0	0	0	0
NSW	5	0	0	0	0	0	0	0	0	0	0
NSW	6	-0	0	0	-0	0	-0	0	0	-0	3
NSW	7	-0	0	0	-0	1	-0	0	0	-0	13
NSW	8	0	0	0	0	0	0	0	0	0	0
VIC	4	0	0	0	0	0	0	0	0	0	0
VIC	6	0	0	0	0	0	0	0	0	0	0
VIC	7	0	0	0	0	0	0	0	0	0	0

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	
VIC	8	0	0	0	0	0	0	0	0	0	0
QLD	1	0	0	0	0	0	0	0	0	0	0
QLD	2	0	0	0	0	0	0	0	0	0	0
QLD	3	0	0	0	0	0	0	0	0	0	0
QLD	5	0	0	0	0	0	0	0	0	0	0
SA	4	0	0	0	0	0	0	0	0	0	0
SA	5	0	0	0	0	0	0	0	0	0	0
SA	6	**-0**	0	0	**-0**	5	**-2**	0	0	**-2**	98
WA	1	0	0	0	0	0	0	0	0	0	0
WA	3	0	0	0	0	0	0	0	0	0	0
WA	4	0	0	0	0	0	0	0	0	0	0
WA	5	0	0	0	0	0	0	0	0	0	0
WA	6	**-13**	0	0	**-13**	683	**-273**	0	0	**-273**	13,655
TAS	7	**-5**	0	0	**-5**	332	**-110**	0	0	**-110**	6,649
NT	1	0	0	0	0	0	0	0	0	0	0
NT	3	0	0	0	0	0	0	0	0	0	0
ACT	7	**-3**	0	0	**-3**	261	**-67**	0	0	**-67**	5,218

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest.

Source: ACIL Allen based on EES data.

Table D.8 Estimated changes in energy consumption under Option B — upgrade pathway for Class 1 dwellings with 7 stars and with PVs installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), MJ per dwelling

		Change in annual energy consumption (MJ)				Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ)				Total PV exports (2022-2060 MJ)
Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total		Electricity	Gas	LPG and firewood	Total	
NSW	2	0	0	0	0	0	0	0	0	0	0
NSW	4	0	0	0	0	0	0	0	0	0	0
NSW	5	0	0	0	0	0	0	0	0	0	0
NSW	6	0	0	0	0	0	0	0	0	0	0
NSW	7	0	0	0	0	0	0	0	0	0	0
NSW	8	0	0	0	0	0	0	0	0	0	0
VIC	4	0	0	0	0	0	0	0	0	0	0
VIC	6	0	0	0	0	0	0	0	0	0	0
VIC	7	0	0	0	0	0	0	0	0	0	0
VIC	8	0	0	0	0	0	0	0	0	0	0
QLD	1	0	0	0	0	0	0	0	0	0	0
QLD	2	0	0	0	0	0	0	0	0	0	0
QLD	3	0	0	0	0	0	0	0	0	0	0
QLD	5	0	0	0	0	0	0	0	0	0	0
SA	4	0	0	0	0	0	0	0	0	0	0
SA	5	0	0	0	0	0	0	0	0	0	0
SA	6	0	0	0	0	0	0	0	0	0	0
WA	1	0	0	0	0	0	0	0	0	0	0
WA	3	0	0	0	0	0	0	0	0	0	0

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
WA	4	0	0	0	0	0	0	0	0	0	0
WA	5	0	0	0	0	0	0	0	0	0	0
WA	6	-1	0	0	-1	35	-15	0	0	-15	692
TAS	7	-2	0	0	-2	83	-33	0	0	-33	1,661
NT	1	0	0	0	0	0	0	0	0	0	0
NT	3	0	0	0	0	0	0	0	0	0	0
ACT	7	-0	0	0	-0	17	-4	0	0	-4	332

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest.

Source: ACIL Allen based on EES data.

Table D.9 Estimated changes in energy consumption under Option A— upgrade pathway for Class 1 dwellings with 6 stars and with a pool or spa installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
NSW	2	-2,141	0	0	-2,141	0	-28,020	0	0	-28,020	0
NSW	4	-8,287	0	0	-8,287	8,414	-169,048	0	0	-169,048	168,289
NSW	5	-7,286	0	0	-7,286	7,027	-140,524	0	0	-140,524	140,536
NSW	6	-7,359	0	0	-7,359	6,460	-145,087	0	0	-145,087	129,198

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	**-9,298**	0	0	**-9,298**	6,662	**-198,743**	0	0	**-198,743**	133,233
NSW	8	**-8,366**	0	0	**-8,366**	6,876	**-178,317**	0	0	**-178,317**	137,516
VIC	4	**-8,287**	0	0	**-8,287**	8,414	**-169,048**	0	0	**-169,048**	168,289
VIC	6	**-7,359**	0	0	**-7,359**	6,460	**-145,087**	0	0	**-145,087**	129,198
VIC	7	**-9,298**	0	0	**-9,298**	6,662	**-198,743**	0	0	**-198,743**	133,233
VIC	8	**-8,366**	0	0	**-8,366**	6,876	**-178,317**	0	0	**-178,317**	137,516
QLD	1	**-3,048**	0	0	**-3,048**	0	**-55,217**	0	0	**-55,217**	0
QLD	2	**-330**	0	0	**-330**	0	**-9,913**	0	0	**-9,913**	0
QLD	3	**-3,196**	0	0	**-3,196**	0	**-59,659**	0	0	**-59,659**	0
QLD	5	**-568**	0	0	**-568**	0	**-17,028**	0	0	**-17,028**	0
SA	4	**-8,287**	0	0	**-8,287**	8,414	**-169,048**	0	0	**-169,048**	168,289
SA	5	**-8,206**	0	0	**-8,206**	7,255	**-165,233**	0	0	**-165,233**	145,098
SA	6	**-7,359**	0	0	**-7,359**	6,460	**-145,087**	0	0	**-145,087**	129,198
WA	1	**-8,982**	0	0	**-8,982**	7,672	**-192,164**	0	0	**-192,164**	153,436
WA	3	**-9,429**	0	0	**-9,429**	9,067	**-204,594**	0	0	**-204,594**	181,344
WA	4	**-2,936**	0	0	**-2,936**	0	**-51,881**	0	0	**-51,881**	0
WA	5	**-2,478**	0	0	**-2,478**	0	**-38,125**	0	0	**-38,125**	0
WA	6	**-2,764**	0	0	**-2,764**	0	**-46,701**	0	0	**-46,701**	0
TAS	7	**-2,449**	0	0	**-2,449**	0	**-50,453**	0	0	**-50,453**	0
NT	1	**-10,538**	0	0	**-10,538**	7,543	**-249,912**	0	0	**-249,912**	150,856

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	
NT	3	**-9,429**	0	0	**-9,429**	9,067	**-204,594**	0	0	**-204,594**	181,344
ACT	7	**-3,142**	0	0	**-3,142**	0	**-58,036**	0	0	**-58,036**	0

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest.

Source: ACIL Allen based on EES data.

Table D.10 Estimated changes in energy consumption under Option B — upgrade pathway for Class 1 dwellings with 6 stars and with a pool or spa installed under the BAU (lowest cost upgrade pathway of two alternative response options analysed), 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	**-330**	0	0	**-330**	0	**-9,913**	0	0	**-9,913**	0
NSW	4	**-1,126**	0	0	**-1,126**	0	**-33,773**	0	0	**-33,773**	0
NSW	5	**-568**	0	0	**-568**	0	**-17,028**	0	0	**-17,028**	0
NSW	6	**-953**	0	0	**-953**	0	**-28,594**	0	0	**-28,594**	0
NSW	7	**-1,331**	0	0	**-1,331**	0	**-39,929**	0	0	**-39,929**	0
NSW	8	**-1,840**	0	0	**-1,840**	0	**-55,189**	0	0	**-55,189**	0
VIC	4	**-2,936**	0	0	**-2,936**	0	**-51,881**	0	0	**-51,881**	0
VIC	6	**-2,764**	0	0	**-2,764**	0	**-46,701**	0	0	**-46,701**	0
VIC	7	**-3,142**	0	0	**-3,142**	0	**-58,036**	0	0	**-58,036**	0

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Annual PV exports (MJ)	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total	Total PV exports (2022-2060 MJ)
VIC	8	**-8,366**	0	0	**-8,366**	6,876	**-178,317**	0	0	**-178,317**	137,516
QLD	1	**-1,237**	0	0	**-1,237**	0	**-37,110**	0	0	**-37,110**	0
QLD	2	**-330**	0	0	**-330**	0	**-9,913**	0	0	**-9,913**	0
QLD	3	**-1,385**	0	0	**-1,385**	0	**-41,552**	0	0	**-41,552**	0
QLD	5	**-568**	0	0	**-568**	0	**-17,028**	0	0	**-17,028**	0
SA	4	**-1,126**	0	0	**-1,126**	0	**-33,773**	0	0	**-33,773**	0
SA	5	**-919**	0	0	**-919**	0	**-27,566**	0	0	**-27,566**	0
SA	6	**-953**	0	0	**-953**	0	**-28,594**	0	0	**-28,594**	0
WA	1	**-1,237**	0	0	**-1,237**	0	**-37,110**	0	0	**-37,110**	0
WA	3	**-1,385**	0	0	**-1,385**	0	**-41,552**	0	0	**-41,552**	0
WA	4	**-1,126**	0	0	**-1,126**	0	**-33,773**	0	0	**-33,773**	0
WA	5	**-667**	0	0	**-667**	0	**-20,018**	0	0	**-20,018**	0
WA	6	**-953**	0	0	**-953**	0	**-28,594**	0	0	**-28,594**	0
TAS	7	**-1,298**	0	0	**-1,298**	0	**-38,938**	0	0	**-38,938**	0
NT	1	**-10,538**	0	0	**-10,538**	7,543	**-249,912**	0	0	**-249,912**	150,856
NT	3	**-2,537**	0	0	**-2,537**	0	**-53,067**	0	0	**-53,067**	0
ACT	7	**-1,331**	0	0	**-1,331**	0	**-39,929**	0	0	**-39,929**	0

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 4. Positive numbers indicate increases in energy consumption and negatives numbers denote decreases in energy consumption. N/A notes where there are no buildings assumed to use this upgrade pathway in the modelling in the jurisdiction/climate zone of interest.

Source: ACIL Allen based on EES data.

D.2 Class 2 dwellings

This section presents the energy flows tables for Class 2 dwellings.

Table D.11 Estimated changes in energy consumption under Option A — upgrade pathway for Class 2 dwellings with 6 stars in the BAU (all equipment upgrade pathway), MJ per dwelling

		Change in annual energy consumption (MJ)				Change in energy consumption, total 2022-2060 (MJ)			
Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
NSW	2	860	-7,418	0	-6,558	9,736	-89,094	0	-79,358
NSW	4	494	-7,707	0	-7,213	-1,023	-93,772	-5	-94,801
NSW	5	713	-7,570	0	-6,857	5,454	-91,101	-1	-85,648
NSW	6	891	-8,322	0	-7,431	7,295	-100,716	-3	-93,424
NSW	7	533	-8,627	0	-8,094	-922	-105,653	-8	-106,583
VIC	6	1,246	-9,697	0	-8,451	1,198	-120,264	0	-119,066
VIC	7	445	-10,331	0	-9,886	-21,265	-133,878	0	-155,142
QLD	1	-2,662	-314	0	-2,976	-14,575	-3,768	0	-18,343
QLD	2	-3,587	-317	0	-3,904	-39,429	-3,820	0	-43,249
QLD	5	-3,864	-325	0	-4,189	-45,195	-3,942	0	-49,137
SA	5	751	-7,786	0	-7,035	7,213	-98,161	0	-90,948
WA	5	1,517	-8,152	0	-6,635	23,690	-103,976	0	-80,286
TAS	7	-4,185	-2,567	0	-6,751	-61,511	-35,489	0	-97,000
NT	1	-3,612	-211	0	-3,823	-69,989	-2,537	0	-72,527

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total
ACT	7	-1,684	-5,592	0	-7,276	-30,848	-76,144	0	-106,992

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 4. 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 D.12 Estimated changes in energy consumption under Option B — upgrade pathway for Class 2 dwellings with 6 stars in the BAU (all equipment upgrade pathway), MJ per dwelling

		Change in annual energy consumption (MJ)				Change in energy consumption, total 2022-2060 (MJ)			
Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
NSW	2	1,486	-7,418	0	-5,933	9,736	-89,094	0	-79,358
NSW	4	1,148	-7,707	0	-6,559	-1,023	-93,772	-5	-94,801
NSW	5	1,366	-7,570	0	-6,204	13,141	-91,101	-1	-77,960
NSW	6	1,576	-8,322	0	-6,747	15,200	-100,715	-3	-85,518
NSW	7	1,253	-8,627	0	-7,374	7,114	-105,639	-8	-98,533
VIC	6	1,717	-9,697	0	-7,981	15,295	-120,264	0	-104,970
VIC	7	1,328	-10,325	0	-8,997	5,266	-133,697	0	-128,431
QLD	1	-170	-309	0	-480	-6,410	-3,714	0	-10,124
QLD	2	6	-317	0	-311	-1,133	-3,820	0	-4,953
QLD	5	-92	-325	0	-417	-4,091	-3,942	0	-8,032
SA	5	751	-7,786	0	-7,035	7,213	-98,161	0	-90,948

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total
WA	5	1,529	-8,152	0	-6,623	23,698	-103,976	0	-80,278
TAS	7	-2,992	-2,567	0	-5,559	-47,312	-35,489	0	-82,801
NT	1	-2,556	-211	0	-2,767	-30,792	-2,533	0	-33,325
ACT	7	-816	-5,576	0	-6,392	-20,603	-75,694	0	-96,298

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 4. 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 D.13 Estimated changes in energy consumption under Option A — upgrade pathway for Class 2 dwellings with 7 stars in the BAU (all equipment upgrade pathway), MJ per dwelling

Jurisdiction	NCC climate	Change in annual energy consumption (MJ) Electricity	Gas	LPG and firewood	Total	Change in energy consumption, total 2022-2060 (MJ) Electricity	Gas	LPG and firewood	Total
NSW	2	968	-7,419	0	-6,451	12,951	-89,105	0	-76,154
NSW	4	1,049	-7,678	0	-6,629	15,623	-92,915	-1	-77,294
NSW	5	950	-7,570	0	-6,619	12,581	-91,100	-1	-78,519
NSW	6	1,212	-8,312	0	-7,100	16,922	-100,399	-1	-83,478
NSW	7	1,201	-8,606	0	-7,405	19,105	-105,003	-3	-85,901
VIC	6	1,601	-9,647	0	-8,046	11,866	-118,761	0	-106,894
VIC	7	1,171	-10,224	0	-9,052	537	-130,657	0	-130,120
QLD	1	-2,370	-314	0	-2,684	-5,824	-3,769	0	-9,593

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
QLD	2	-3,509	-317	0	-3,826	-37,077	-3,824	0	-40,900
QLD	5	-3,688	-325	0	-4,013	-39,913	-3,960	0	-43,873
SA	5	1,038	-7,808	0	-6,770	15,833	-98,821	0	-82,988
WA	5	1,811	-8,180	0	-6,369	32,507	-104,813	0	-72,307
TAS	7	-3,490	-2,532	0	-6,022	-40,678	-34,444	0	-75,122
NT	1	-3,098	-211	0	-3,309	-54,571	-2,537	0	-57,109
ACT	7	-966	-5,552	0	-6,518	-9,291	-74,950	0	-84,241

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 4. 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 D.14 Estimated changes in energy consumption under Option B — upgrade pathway for Class 2 dwellings with 7 stars in the BAU (all equipment upgrade pathway), 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	1,593	-7,419	0	-5,826	12,951	-89,105	0	-76,154
NSW	4	1,702	-7,678	0	-5,976	15,623	-92,915	-1	-77,294
NSW	5	1,603	-7,570	0	-5,966	20,269	-91,100	-0	-70,831
NSW	6	1,897	-8,312	0	-6,415	24,828	-100,399	-1	-75,572
NSW	7	1,920	-8,605	0	-6,685	27,141	-104,989	-3	-77,852

		Change in annual energy consumption (MJ)				Change in energy consumption, total 2022-2060 (MJ)			
Jurisdiction	NCC climate	Electricity	Gas	LPG and firewood	Total	Electricity	Gas	LPG and firewood	Total
VIC	6	2,072	-9,647	0	-7,575	25,963	-118,761	0	-92,798
VIC	7	2,055	-10,217	0	-8,163	27,068	-130,476	0	-103,408
QLD	1	121	-309	0	-188	2,341	-3,715	0	-1,374
QLD	2	85	-317	0	-233	1,219	-3,824	0	-2,604
QLD	5	84	-325	0	-241	1,191	-3,960	0	-2,769
SA	5	1,038	-7,808	0	-6,770	15,833	-98,821	0	-82,988
WA	5	1,823	-8,180	0	-6,357	32,515	-104,813	0	-72,298
TAS	7	-2,297	-2,532	0	-4,829	-26,479	-34,444	0	-60,923
NT	1	-2,042	-211	0	-2,253	-15,374	-2,533	0	-17,907
ACT	7	-98	-5,536	0	-5,634	953	-74,500	0	-73,547

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 4. 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.

State and territory results E

This appendix presents the estimated costs and benefits of the proposed policy options for the NCC 2022 on individual states and territories of Australia.

Table E.1 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), NSW

	Option A	Option B
COSTS		
Households - capital (resource) costs	916.6	814.1
Industry	22.0	22.0
Government Costs	0.2	0.2
TOTAL COSTS	**938.9**	**836.4**
BENEFITS		
Households		
Electricity savings	28.5	**-12.1**
Gas savings	189.7	190.4
LPG and firewood savings	4.6	4.6
Household subtotal	**222.8**	**182.8**
Society		
Deferred network investment for gas and electricity	**-3.5**	**-5.3**
Greenhouse emissions savings	42.9	33.0
Health benefits from improved air quality	34.8	5.2
Society subtotal	**74.2**	**32.8**
TOTAL BENEFITS	**297.0**	**215.6**
NET PRESENT VALUES		
Accounting for energy benefits only	**-719.6**	**-658.9**
Accounting for energy benefits + carbon benefits	**-676.7**	**-625.9**
Accounting for energy benefits + carbon benefits + health benefits	**-641.9**	**-620.8**

	Option A	Option B
BCR (RATIO)		
Accounting for energy benefits only	0.23	0.21
Accounting for energy benefits + carbon benefits	0.28	0.25
Accounting for energy benefits + carbon benefits + health benefits	0.32	0.26

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.2 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Victoria

	Option A	Option B
COSTS		
Households - capital (resource) costs	1,417.4	803.5
Industry	18.5	18.5
Government Costs	0.2	0.2
TOTAL COSTS	**1,436.1**	**822.2**
BENEFITS		
Households		
Electricity savings	261.7	29.3
Gas savings	80.4	125.5
LPG and firewood savings	12.3	17.1
Household subtotal	**354.5**	**171.9**
Society		
Deferred network investment for gas and electricity	49.1	2.1
Greenhouse emissions savings	103.5	26.9
Health benefits from improved air quality	35.2	3.9
Society subtotal	**187.8**	**33.0**
TOTAL BENEFITS	**542.3**	**204.9**
NET PRESENT VALUES		
Accounting for energy benefits only	**-1,032.5**	**-648.2**
Accounting for energy benefits + carbon benefits	**-929.0**	**-621.3**
Accounting for energy benefits + carbon benefits + health benefits	**-893.8**	**-617.4**

	Option A	Option B
BCR (RATIO)		
Accounting for energy benefits only	0.28	0.21
Accounting for energy benefits + carbon benefits	0.35	0.24
Accounting for energy benefits + carbon benefits + health benefits	0.38	0.25

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.3 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Queensland

	Option A	Option B
COSTS		
Households - capital (resource) costs	455.4	189.4
Industry	12.3	12.3
Government Costs	0.1	0.1
TOTAL COSTS	**467.8**	**201.9**
BENEFITS		
Households		
Electricity savings	68.8	8.7
Gas savings	4.0	4.0
LPG and firewood savings	0.2	0.1
Household subtotal	**73.0**	**12.8**
Society		
Deferred network investment for gas and electricity	7.4	2.4
Greenhouse emissions savings	22.2	2.9
Health benefits from improved air quality	42.0	0.5
Society subtotal	**71.6**	**5.8**
TOTAL BENEFITS	**144.5**	**18.6**
NET PRESENT VALUES		
Accounting for energy benefits only	**-387.4**	**-186.7**
Accounting for energy benefits + carbon benefits	**-365.3**	**-183.8**
Accounting for energy benefits + carbon benefits + health benefits	**-323.3**	**-183.3**

	Option A	Option B
BCR (RATIO)		
Accounting for energy benefits only	0.17	0.08
Accounting for energy benefits + carbon benefits	0.22	0.09
Accounting for energy benefits + carbon benefits + health benefits	0.31	0.09

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.4 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), South Australia

	Option A	Option B
COSTS		
Households - capital (resource) costs	133.3	108.2
Industry	3.8	3.8
Government Costs	0.04	0.04
TOTAL COSTS	**137.2**	**112.1**
BENEFITS		
Households		
Electricity savings	15.2	4.6
Gas savings	23.4	23.1
LPG and firewood savings	2.5	1.8
Household subtotal	**41.2**	**29.6**
Society		
Deferred network investment for gas and electricity	1.3	0.9
Greenhouse emissions savings	6.0	4.7
Health benefits from improved air quality	5.1	0.7
Society subtotal	**12.5**	**6.2**
TOTAL BENEFITS	**53.6**	**35.8**
NET PRESENT VALUES		
Accounting for energy benefits only	**-94.7**	**-81.6**
Accounting for energy benefits + carbon benefits	**-88.7**	**-77.0**
Accounting for energy benefits + carbon benefits + health benefits	**-83.6**	**-76.3**
BCR (RATIO)		
Accounting for energy benefits only	0.31	0.27
Accounting for energy benefits + carbon benefits	0.35	0.31

	Option A	Option B
Accounting for energy benefits + carbon benefits + health benefits	0.39	0.32

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.5 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Western Australia

	Option A	Option B
COSTS		
Households - capital (resource) costs	268.7	254.4
Industry	6.0	6.0
Government Costs	0.1	0.1
TOTAL COSTS	**274.7**	**260.5**
BENEFITS		
Households		
Electricity savings	18.0	11.3
Gas savings	34.7	34.7
LPG and firewood savings	1.8	1.7
Household subtotal	**54.4**	**47.7**
Society		
Deferred network investment for gas and electricity	3.1	1.9
Greenhouse emissions savings	11.9	10.6
Health benefits from improved air quality	1.8	1.6
Society subtotal	**16.7**	**14.1**
TOTAL BENEFITS	**71.1**	**61.8**
NET PRESENT VALUES		
Accounting for energy benefits only	**-217.2**	**-210.9**
Accounting for energy benefits + carbon benefits	**-205.4**	**-200.3**
Accounting for energy benefits + carbon benefits + health benefits	**-203.6**	**-198.7**
BCR (RATIO)		
Accounting for energy benefits only	0.21	0.19
Accounting for energy benefits + carbon benefits	0.25	0.23
Accounting for energy benefits + carbon benefits + health benefits	0.26	0.24

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.6 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Tasmania

	Option A	Option B
COSTS		
Households - capital (resource) costs	61.5	43.4
Industry	1.1	1.1
Government Costs	0.01	0.01
TOTAL COSTS	**62.6**	**44.5**
BENEFITS		
Households		
Electricity savings	8.1	3.0
Gas savings	3.5	3.5
LPG and firewood savings	8.8	5.5
Household subtotal	20.4	11.9
Society		
Deferred network investment for gas and electricity	0.9	0.8
Greenhouse emissions savings	1.0	0.7
Health benefits from improved air quality	0.1	0.1
Society subtotal	**1.9**	**1.6**
TOTAL BENEFITS	**22.4**	**13.5**
NET PRESENT VALUES		
Accounting for energy benefits only	**-41.3**	**-31.8**
Accounting for energy benefits + carbon benefits	**-40.4**	**-31.1**
Accounting for energy benefits + carbon benefits + health benefits	**-40.3**	**-31.0**
BCR (RATIO)		
Accounting for energy benefits only	0.34	0.29
Accounting for energy benefits + carbon benefits	0.36	0.30
Accounting for energy benefits + carbon benefits + health benefits	0.36	0.30

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.7 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), Northern Territory

	Option A	Option B
COSTS		
Households - capital (resource) costs	64.5	28.3
Industry	0.4	0.4
Government Costs	0.004	0.004
TOTAL COSTS	**64.9**	**28.7**
BENEFITS		
Households		
Electricity savings	45.0	13.1
Gas savings	0.03	0.05
LPG and firewood savings	0.00	0.00
Household subtotal	**45.1**	**13.1**
Society		
Deferred network investment for gas and electricity	3.4	1.5
Greenhouse emissions savings	3.7	1.1
Health benefits from improved air quality	0.3	0.1
Society subtotal	**7.4**	**2.7**
TOTAL BENEFITS	**52.4**	**15.9**
NET PRESENT VALUES		
Accounting for energy benefits only	**-16.4**	**-14.0**
Accounting for energy benefits + carbon benefits	**-12.7**	**-12.9**
Accounting for energy benefits + carbon benefits + health benefits	**-12.4**	**-12.8**
BCR (RATIO)		
Accounting for energy benefits only	0.75	0.51
Accounting for energy benefits + carbon benefits	0.80	0.55
Accounting for energy benefits + carbon benefits + health benefits	0.81	0.55

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Table E.8 Estimated costs and benefits of the proposed policy options, present value ($M, 2021), ACT

	Option A	Option B
COSTS		
Households - capital (resource) costs	75.5	65.3
Industry	0.9	0.9
Government Costs	0.01	0.01
TOTAL COSTS	**76.4**	**66.3**
BENEFITS		
Households		
Electricity savings	8.9	4.5
Gas savings	13.7	13.7
LPG and firewood savings	0.6	0.4
Household subtotal	**23.2**	**18.5**
Society		
Deferred network investment for gas and electricity	0.9	1.6
Greenhouse emissions savings	4.2	3.3
Health benefits from improved air quality	0.5	0.4
Society subtotal	**5.5**	**5.2**
TOTAL BENEFITS	**28.7**	**23.8**
NET PRESENT VALUES		
Accounting for energy benefits only	**-52.4**	**-46.2**
Accounting for energy benefits + carbon benefits	**-48.1**	**-42.9**
Accounting for energy benefits + carbon benefits + health benefits	**-47.7**	**-42.5**
BCR (RATIO)		
Accounting for energy benefits only	0.31	0.30
Accounting for energy benefits + carbon benefits	0.37	0.35
Accounting for energy benefits + carbon benefits + health benefits	0.38	0.36

Note: Using a 7 per cent discount rate. Totals may not add up due to rounding.
Source: ACIL Allen.

Wholesale electricity market modelling – assumptions

F

This Appendix describes the assumptions that have been used in the wholesale electricity market modelling.

The scenarios modelled are as set out in Table F.1.

Table F.1 Scenarios modelled

Scenario	Description
Reference case	Standard ACIL Allen reference case as at March 2021
Scenario 1	NCC 2022 proposal, Option A
Scenario 2	As per scenario 1 with twice as much solar PV capacity installed

The assumptions that have been specifically made for scenarios 1 and 2 are described in Appendix F.2.2. All other assumptions are the same as for the reference case.

F.1 Macro assumptions

Inflation and foreign exchange assumptions are used in the escalation of nominal input costs for generators (fuel, variable O&M, capital costs for new entrants etc.).

The Brent crude oil price and the Newcastle FOB coal price are input assumptions for ACIL Allen's gas and coal price projections, respectively.

Inflation

ACIL Allen undertakes the market modelling in nominal terms and therefore uses an explicit inflation assumption to escalate cost inputs relative to this index. Inflation is measured as the change in the Consumer Price Index (CPI) on an annual basis. The assumption used throughout is 2.5 per cent per annum, which corresponds to the mid-point of the Reserve Bank inflation target range.

Foreign exchange rate

The Australian dollar is assumed to hold constant at the long-term average of 0.75 USD/AUD throughout the projection period. The basis of this assumption is that the Australian dollar is a commodity currency which tracks reasonably closely with commodity prices in the long term.

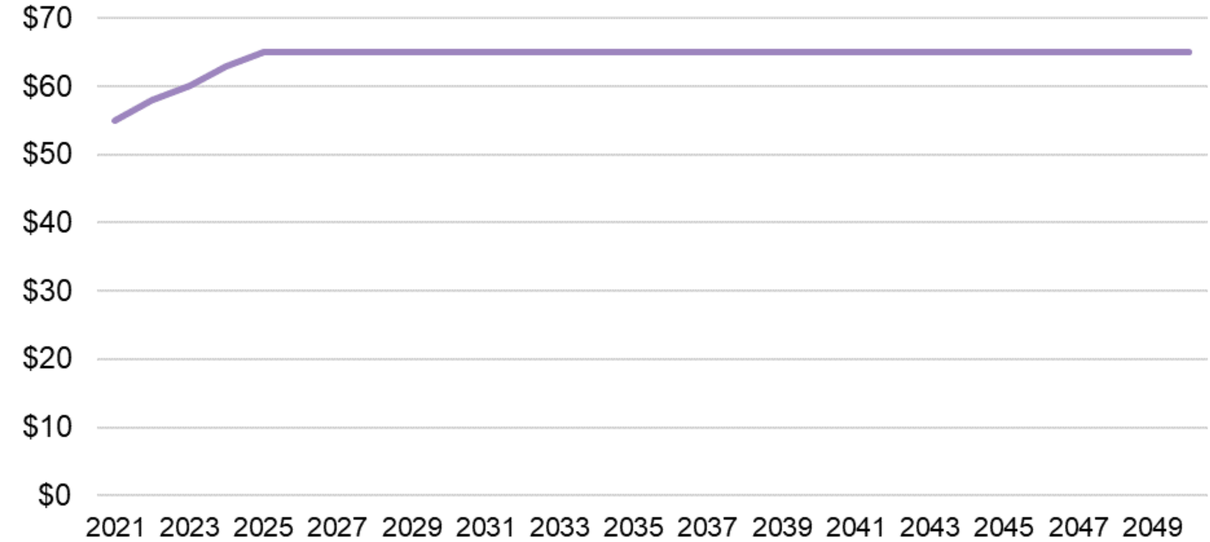
Brent crude oil price

The domestic gas market is linked to the international market through the LNG export plants in Gladstone. As a result, movements in global oil prices have an important influence on domestic gas prices.

The principal pricing model for LNG contracts in the Asia Pacific region is oil-linked pricing based around the Japanese Customs-cleared Crude (JCC) price, a close proxy to the Brent crude price (see Figure F.1).

Fluctuation in oil prices has a direct flow-on effect to the price of LNG produced in Australia because most long-term LNG contracts (including those written by the three Gladstone LNG projects) have a formulaic link to the JCC oil price.

Figure F.1 Assumed Brent crude oil price ($US/barrel, real 2021)



Source: ACIL Allen February 2021 quarterly gas price report

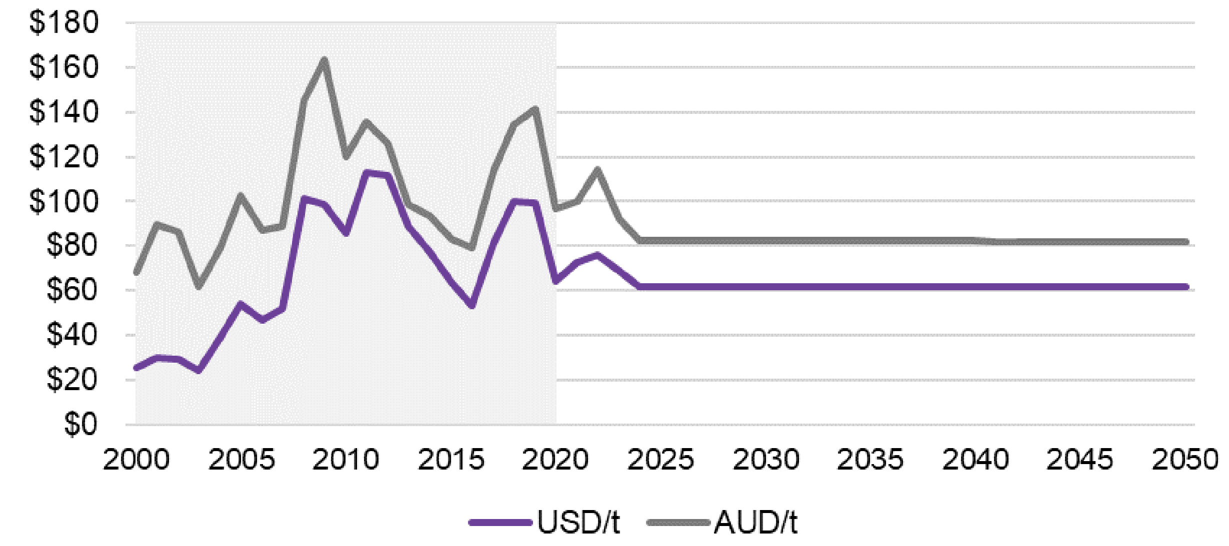
Export coal price

The Newcastle Free on Board (FOB) price for thermal coal is an important consideration in the price formation for all new coal contracts in New South Wales and for some in Queensland. The projection of these prices underlies the projected future export parity value of the Run of Mine (ROM) coal at each location which is an important consideration in setting the likely delivered price into local power stations.

Export prices declined dramatically during the second half of 2019 and early 2020 as supply growth outpaced demand – returning coal prices to levels more reflective of the marginal cost of supply. Since late 2020 export prices have increased in response to stronger Asian demand, which is driven by the region's economic recovery after COVID-19's impacts in 2020 as well as cold winter conditions. Supply from some producers had been curtailed in 2020 in response to the low export prices, resulting in a tighter thermal coal market.

As illustrated in Figure F.2, the reference case assumes that export coal prices will peak at USD$76/t in real 2021 terms in 2022, before falling to USD$62/t in real 2021 terms by 2024 and remaining at this level for the remainder of the projection horizon.

Figure F.2 Assumed Newcastle FOB prices ($/tonne, real 2021)



Source: ACIL Allen

F.2 Electricity demand

Regional annual energy and peak demand are important inputs to wholesale energy market modelling. *PowerMark* models the segment of the market to be satisfied by the NEM, that is, by scheduled and semi-scheduled generation. This is the underlying demand less rooftop PV output, plus electric vehicle charging requirements and behind-the-meter storage round trip losses.

F.2.1 Reference case

The reference case uses the official projection of regional summer and winter peak demands and annual energy published in the Electricity Statement of Opportunities (ESOO) by the Australian Energy Market Operator (AEMO) in August 2020 as a starting point. The demand projection is based on the Central scenario growth outlook and the 50 per cent probability of exceedance (POE50) level summer peak and winter peak demands.

To these projections ACIL Allen has made the following adjustments:[187]

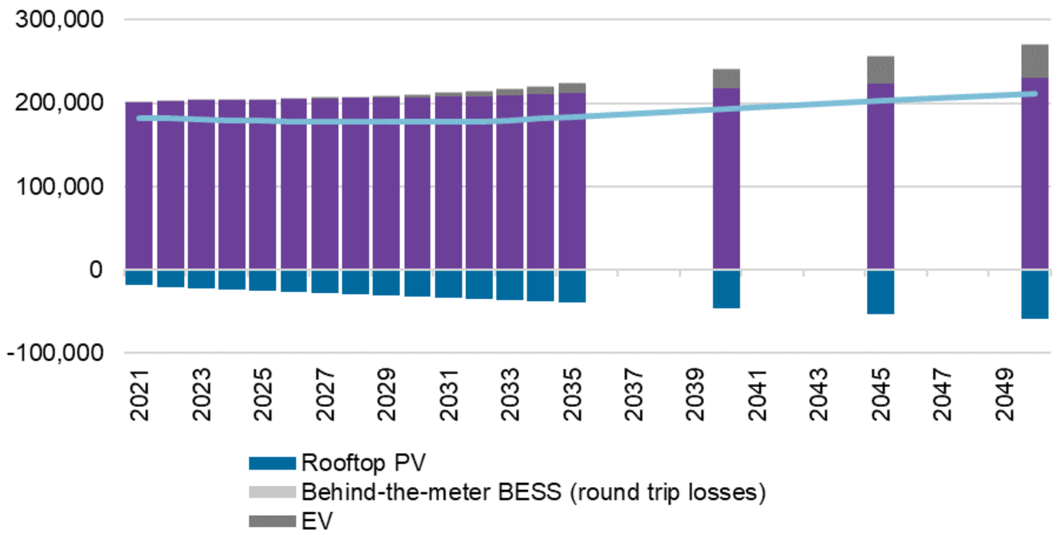
1. ACIL Allen has undertaken and adopted its own projection of the uptake of **rooftop solar PV** and **behind-the-meter storage** for both the residential and commercial sector, which are internally consistent with other assumptions (such as exchange rates, capital costs, network tariffs etc.) adopted in the reference case.

[187] ACIL Allen also deducts an estimate of significant non-scheduled generation from AEMO's operational demand forecast to arrive at a scheduled and semi-scheduled projection (the segment of the market supplied by the NEM).

2. Though ACIL Allen has adopted the projected uptake of **electric vehicles** as forecast by AEMO in its 2020 ESOO, we have used our own charging profiles in our modelling. This is further explained in Appendix G.6.

The resulting NEM-wide energy requirements are shown in Figure F.3.

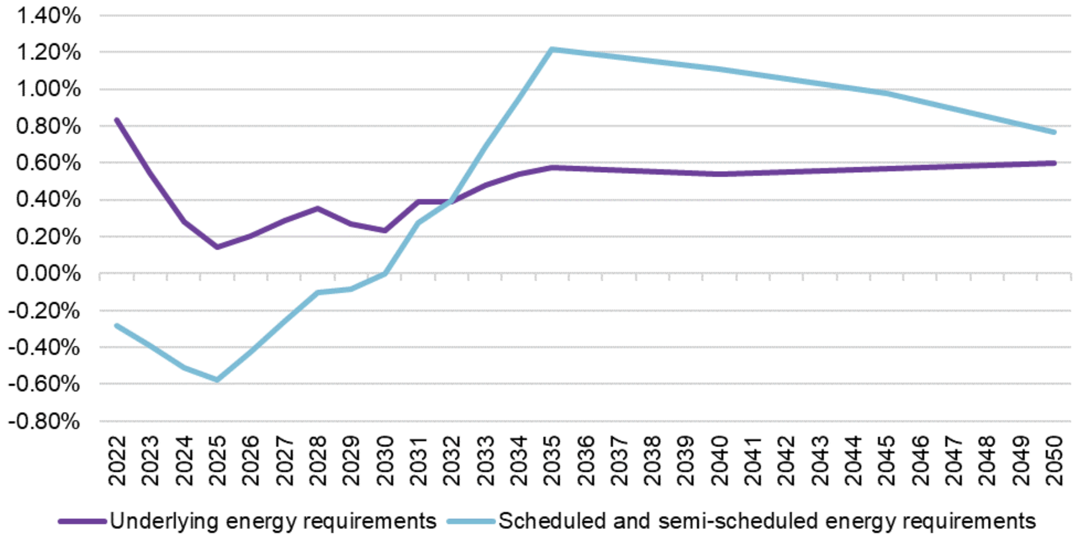
Figure F.3 Assumed NEM energy requirements (GWh, gross)



Source: ACIL Allen

Although there is growth in underlying energy requirements in the initial years of the projection period (as per the ESOO), this is offset by the projected strong uptake in rooftop PV, resulting in a contraction of the scheduled and semi-scheduled energy requirements of up to 0.5 per cent per year in the period to 2030 (see Figure F.4). Post 2030, the projected strong uptake in EVs results in NEM-wide scheduled and semi-scheduled energy requirements growing at around one per cent per year.

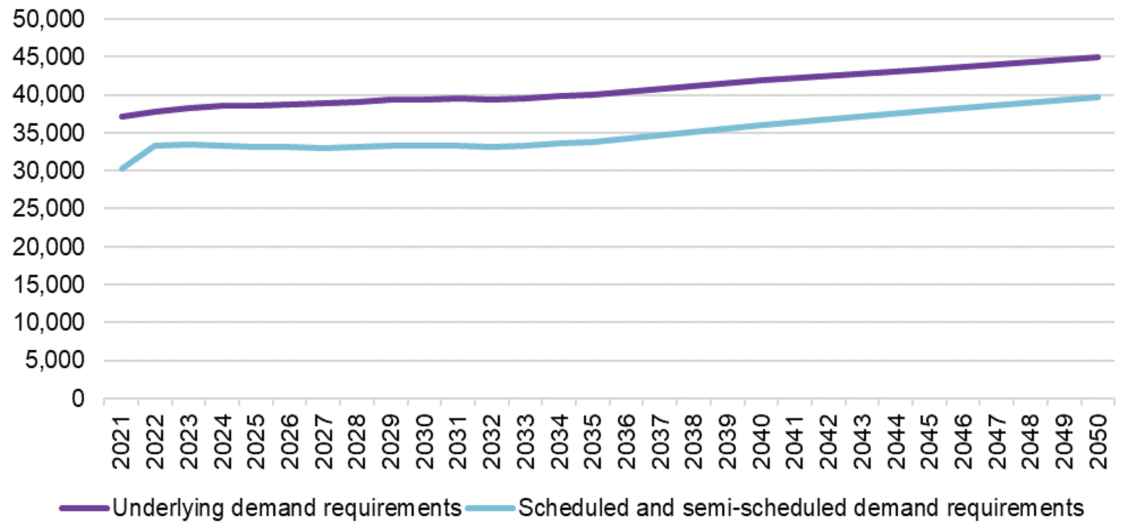
Figure F.4 Annual year on year growth in assumed NEM energy requirements (%)



Source: ACIL Allen

Peak demand typically occurs in the summer months in all regions of the NEM except for Tasmania. On a NEM-wide basis, peak demand is about 5,000 MW lower than what it would be if there were no rooftop PV installations (see Figure F.5). This impact is no longer growing since the current fleet of rooftop PV shifted the timing of the peak from mid-afternoon to the evening in the mid-2010s. Peak demand is not projected to grow until post 2030 which is largely due to the assumed strong increase in EV charging demand.

Figure F.5 Assumed NEM wide peak demand (MW, gross)



Source: ACIL Allen

Further details of the demand and energy assumptions are set out in Appendix G, as are our projections of the uptake of rooftop solar PV and behind-the-meter storage.

The aluminium smelters in the NEM are assumed to continue their operations as per AEMO's Central scenario forecast. Our view on their continued operations is set out in further detail in Appendix G.7.

F.2.2 Scenarios 1 and 2

The inputs to the wholesale energy market modelling for scenario 1 are informed by:

— modelling by Energy Efficiency Strategies of the impact of NCC 2022 on an average building by class, by jurisdiction and by climate zone
— modelling by ACIL Allen to aggregate the building level impacts (housing stock model).

For each building class, jurisdiction and climate zone, the building level model assesses the impact of various BAU scenarios and pathways to comply with the NCC 2022 on:

— energy consumption by fuel type and purpose:
  – heating – peak electricity, off peak electricity, gas, LPG, wood
  – cooling – peak electricity
  – water heating – peak electricity, off peak electricity, gas
  – lighting – peak electricity

  - pool – peak electricity
  - spa – peak electricity
- peak electricity demand – summer, winter
- solar PV
  - size of PV system (maximum)
  - size of PV system (average)
  - electricity generated
  - electricity exported.

The building-level impacts are aggregated based on:

- assumptions about the pathways that different buildings are likely to follow to comply with the new requirements, based on their characteristics under the BAU (e.g. the compliance pathway for buildings currently built with PV in the baseline would be different to those buildings that are not being built with PV)
- assumptions about the proportion of new homes installing PVs at time of construction under the BAU
- projections of the number of new buildings that will be impacted by NCC 2022.

A 10 per cent rebound factor has been assumed.

Solar PV assumptions

The assumptions for the uptake of solar PV under scenario 1 (option A) are described in section 4.2.1.

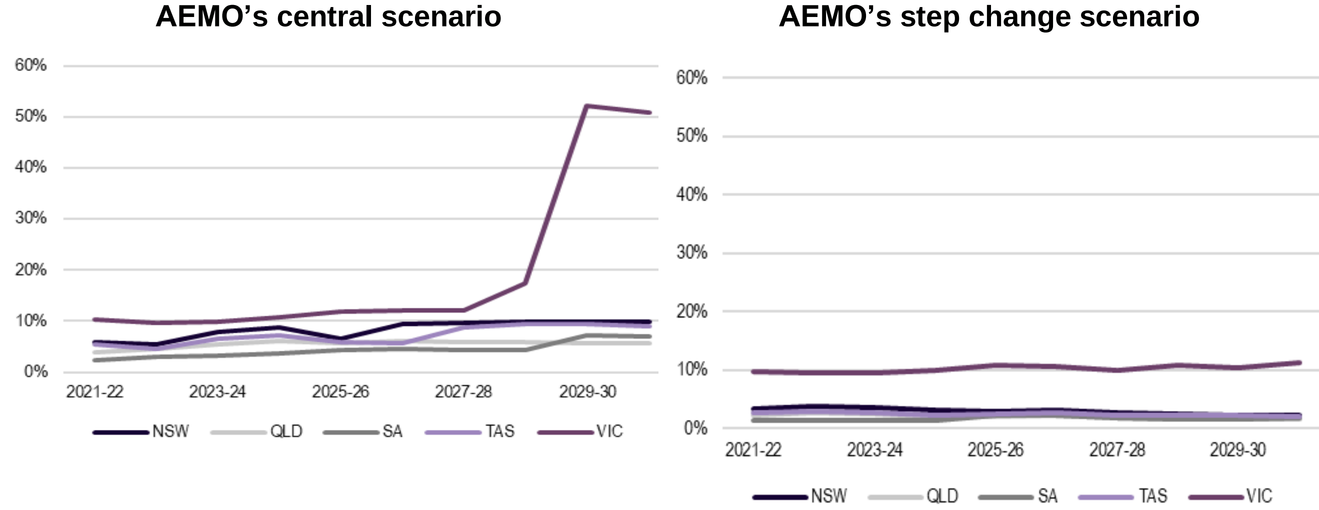
Inputs to the energy market modelling

The inputs to the energy market modelling for scenario 1, derived from the housing stock model, are set out in Table F.2. The impacts of the NCC 2022 are set out for the years 2022-33 only. From 2034, the impacts are expected to decline in line with the asset life of the measures. It should be noted that these inputs were from an earlier version of the housing stock model to those used for the cost benefit analysis. Any differences between the outputs from the housing stock model between those used for the energy market modelling and the latest version used for the cost-benefit analysis are unlikely to have a material impact on the outputs from the energy market modelling.

The extent to which the electricity consumption increases or decreases under NCC 2022 is a function of the amount of fuel switching, and the increases in peak demand are not material.

Figure F.6 illustrates the solar PV capacity that is estimated to be installed under the proposed NCC 2022 (option A, scenario 1) compared to AEMO's projections under the central scenario and the step change scenario. Except for Victoria, the estimated solar PV installations are less than 10 per cent of AEMO's projections under the central scenario and less than 2 per cent under the step change scenario. The estimated PV installations in Victoria are up to 51 per cent of AEMO's projections under the central scenario in the later years and up to 11 per cent of AEMO's projections under the step change scenario.

Figure F.6 New PV installations as a proportion of AEMO projections, scenario 1



Source: ACIL Allen analysis based on AEMO's Draft 2020-21 Inputs and assumptions workbook

Table F.2 Inputs to energy market modelling, scenario 1

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cumulative change in peak electricity consumption (MWh)												
NSW	6,494	13,252	20,902	29,521	38,638	47,779	56,921	66,079	75,566	85,397	85,696	86,020
VIC	-27,549	-53,677	-80,496	-109,429	-141,036	-172,726	-203,083	-231,787	-258,690	-284,751	-284,525	-284,278
QLD	-6,566	-13,274	-20,623	-28,590	-36,672	-44,272	-51,383	-58,318	-64,999	-71,456	-71,347	-71,230
SA	-9	-5	6	37	99	173	259	367	582	897	991	1,105
WA	2,563	5,298	8,267	11,439	14,773	18,077	21,340	24,598	28,470	33,045	33,766	34,527
TAS	-781	-1,551	-2,363	-3,239	-4,170	-5,124	-6,071	-7,011	-7,936	-8,817	-8,807	-8,797
NT	-1,019	-2,225	-3,720	-5,388	-7,360	-9,494	-11,683	-13,873	-16,031	-18,177	-18,140	-18,098
ACT	-73	-152	-238	-333	-431	-531	-633	-738	-836	-928	-918	-907
Cumulative change in off-peak electricity consumption (MWh)												
NSW	-3,134	-6,421	-10,173	-14,430	-18,963	-23,538	-28,141	-32,779	-37,471	-42,223	-42,223	-42,223
VIC	-9	-6	2	19	45	79	119	159	204	243	243	243
QLD	-9,296	-19,071	-30,087	-42,369	-55,179	-67,559	-79,462	-91,386	-103,358	-115,423	-115,423	-115,423
SA	-1,243	-2,438	-3,697	-5,224	-6,931	-8,515	-9,992	-11,448	-12,878	-14,258	-14,258	-14,258
WA	-233	-481	-747	-1,030	-1,326	-1,617	-1,904	-2,187	-2,467	-2,749	-2,749	-2,749
TAS	-971	-1,922	-2,918	-3,987	-5,117	-6,263	-7,393	-8,508	-9,611	-10,666	-10,666	-10,666
NT	-10	-22	-38	-58	-82	-110	-141	-173	-206	-241	-241	-241
ACT	-1,174	-2,405	-3,714	-5,094	-6,497	-7,895	-9,283	-10,662	-12,037	-13,416	-13,416	-13,416

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Total cumulative change in electricity consumption (MWh)[a]												
NSW	3,361	6,830	10,729	15,090	19,675	24,241	28,780	33,300	38,095	43,173	43,472	43,797
VIC	-27,558	-53,684	-80,494	-109,411	-140,991	-172,648	-202,963	-231,628	-258,486	-284,507	-284,282	-284,035
QLD	-15,862	-32,345	-50,709	-70,958	-91,851	-111,830	-130,845	-149,704	-168,358	-186,878	-186,770	-186,653
SA	-1,253	-2,443	-3,691	-5,187	-6,832	-8,342	-9,733	-11,081	-12,296	-13,360	-13,266	-13,153
WA	2,329	4,818	7,520	10,409	13,448	16,459	19,437	22,410	26,003	30,296	31,017	31,778
TAS	-1,752	-3,473	-5,280	-7,226	-9,287	-11,387	-13,464	-15,519	-17,548	-19,483	-19,473	-19,463
NT	-1,028	-2,247	-3,758	-5,446	-7,443	-9,604	-11,824	-14,046	-16,237	-18,418	-18,381	-18,340
ACT	-1,247	-2,557	-3,952	-5,426	-6,928	-8,426	-9,916	-11,401	-12,874	-14,344	-14,334	-14,323
Cumulative change in summer peak demand (MW)												
NSW	0	-1	-1	-2	-3	-4	-6	-7	-8	-10	-10	-10
VIC	-24	-48	-74	-103	-137	-172	-207	-242	-277	-312	-312	-312
QLD	13	27	43	60	78	95	112	128	144	160	160	160
SA	-3	-6	-10	-14	-19	-23	-27	-31	-34	-38	-38	-38
WA	2	5	8	10	13	16	20	23	25	29	29	29
TAS	-2	-4	-6	-9	-11	-13	-16	-18	-21	-23	-23	-23
NT	-1	-2	-3	-4	-5	-7	-9	-10	-12	-14	-14	-14
ACT	-1	-3	-5	-7	-8	-10	-12	-14	-16	-17	-17	-17

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cumulative change in winter peak demand (MW)												
NSW	2	5	8	11	14	17	20	23	27	30	30	30
VIC	-22	-43	-66	-92	-120	-151	-181	-210	-239	-267	-267	-267
QLD	-16	-32	-50	-70	-91	-111	-130	-149	-167	-186	-186	-186
SA	0	0	0	0	-1	-1	-1	-1	-2	-2	-2	-2
WA	10	20	31	43	55	67	79	91	102	114	114	114
TAS	-2	-4	-5	-7	-10	-12	-14	-16	-18	-20	-20	-20
NT	0	0	0	0	0	0	0	0	0	0	0	0
ACT	-3	-6	-10	-13	-17	-21	-24	-28	-31	-35	-35	-35
Cumulative difference in PV capacity (MW)												
NSW	15	30	46	64	82	99	116	131	147	162	162	162
VIC	53	104	157	214	277	340	401	460	516	570	570	570
QLD	8	17	26	36	46	55	64	72	80	88	88	88
SA	2	4	6	9	11	14	16	19	21	23	23	23
WA	2	5	8	10	13	16	19	22	25	28	28	28
TAS	1	1	2	3	4	5	5	6	7	8	8	8
NT	1	3	5	7	9	11	14	16	19	21	21	21
ACT	0	0	1	1	1	2	2	2	2	3	3	3

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cumulative change in energy generated by PV (MWh)												
NSW	19,706	39,362	60,683	83,730	107,150	129,676	151,290	172,081	192,155	211,572	211,572	211,572
VIC	68,067	133,087	200,281	273,291	353,644	434,845	513,272	587,994	659,245	729,344	729,344	729,344
QLD	12,842	25,863	40,018	55,243	70,567	84,860	98,125	110,954	123,391	135,493	135,493	135,493
SA	2,939	5,744	8,684	12,223	16,140	19,748	23,085	26,342	29,517	32,554	32,554	32,554
WA	3,595	7,381	11,436	15,708	20,163	24,539	28,804	33,004	37,119	41,238	41,238	41,238
TAS	847	1,670	2,525	3,433	4,385	5,337	6,267	7,176	8,067	8,910	8,910	8,910
NT	1,986	4,294	7,108	10,198	13,800	17,650	21,551	25,404	29,204	32,982	32,982	32,982
ACT	350	713	1,099	1,501	1,910	2,317	2,717	3,111	3,502	3,891	3,891	3,891
Cumulative difference in energy exported by PV (MWh)												
NSW	12,204	24,376	37,579	51,850	66,353	80,300	93,683	106,555	118,982	131,003	131,003	131,003
VIC	37,392	73,120	110,050	150,184	194,364	239,019	282,157	323,262	362,466	401,036	401,036	401,036
QLD	9,359	18,853	29,180	40,294	51,486	61,931	71,630	81,016	90,120	98,985	98,985	98,985
SA	1,895	3,707	5,614	7,916	10,465	12,819	15,001	17,132	19,214	21,212	21,212	21,212
WA	2,389	4,910	7,614	10,470	13,448	16,374	19,231	22,050	24,818	27,590	27,590	27,590
TAS	507	1,000	1,511	2,054	2,623	3,191	3,746	4,289	4,820	5,323	5,323	5,323
NT	1,140	2,468	4,092	5,879	7,966	10,200	12,466	14,708	16,921	19,124	19,124	19,124
ACT	237	482	742	1,013	1,287	1,560	1,827	2,089	2,349	2,607	2,607	2,607

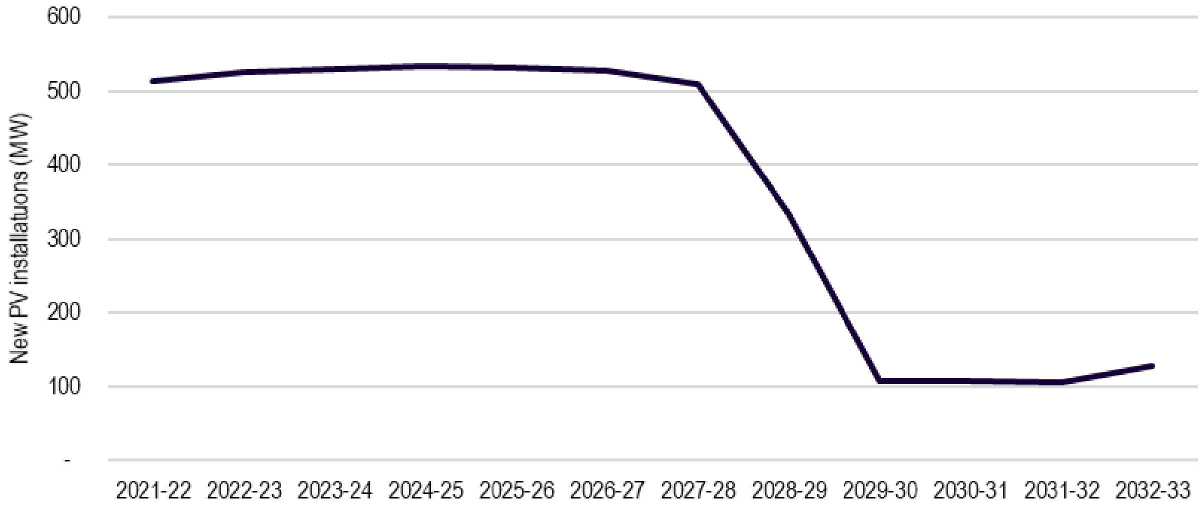
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cumulative change in gas consumption (PJ)												
NSW	-241	-486	-757	-1,055	-1,363	-1,665	-1,961	-2,251	-2,537	-2,819	-2,819	-2,819
VIC	-97	-193	-297	-414	-549	-690	-832	-973	-1,112	-1,254	-1,254	-1,254
QLD	-5	-10	-16	-23	-29	-36	-42	-47	-53	-59	-59	-59
SA	-28	-54	-83	-117	-156	-192	-226	-259	-292	-324	-324	-324
WA	-77	-158	-246	-339	-436	-532	-626	-720	-812	-905	-905	-905
TAS	-4	-8	-12	-16	-20	-25	-30	-34	-39	-43	-43	-43
NT	0	0	0	0	0	0	0	-1	-1	-1	-1	-1
ACT	-16	-33	-51	-70	-89	-109	-128	-147	-166	-185	-185	-185

[a] Totals may not add up due to rounding.

Source: ACIL Allen analysis

The incremental PV capacity in Victoria estimated under the NCC 2022 (option A, scenario 1) is very high relative to AEMO's projections under the central scenario because AEMO projects a significant decrease in new PV capacity in Victoria with the conclusion of the Victorian Government's Solar Homes program, as illustrated in Figure F.7. AEMO projects a decrease in the PV capacity in all jurisdictions under the central scenario, but not to the same extent as in Victoria.

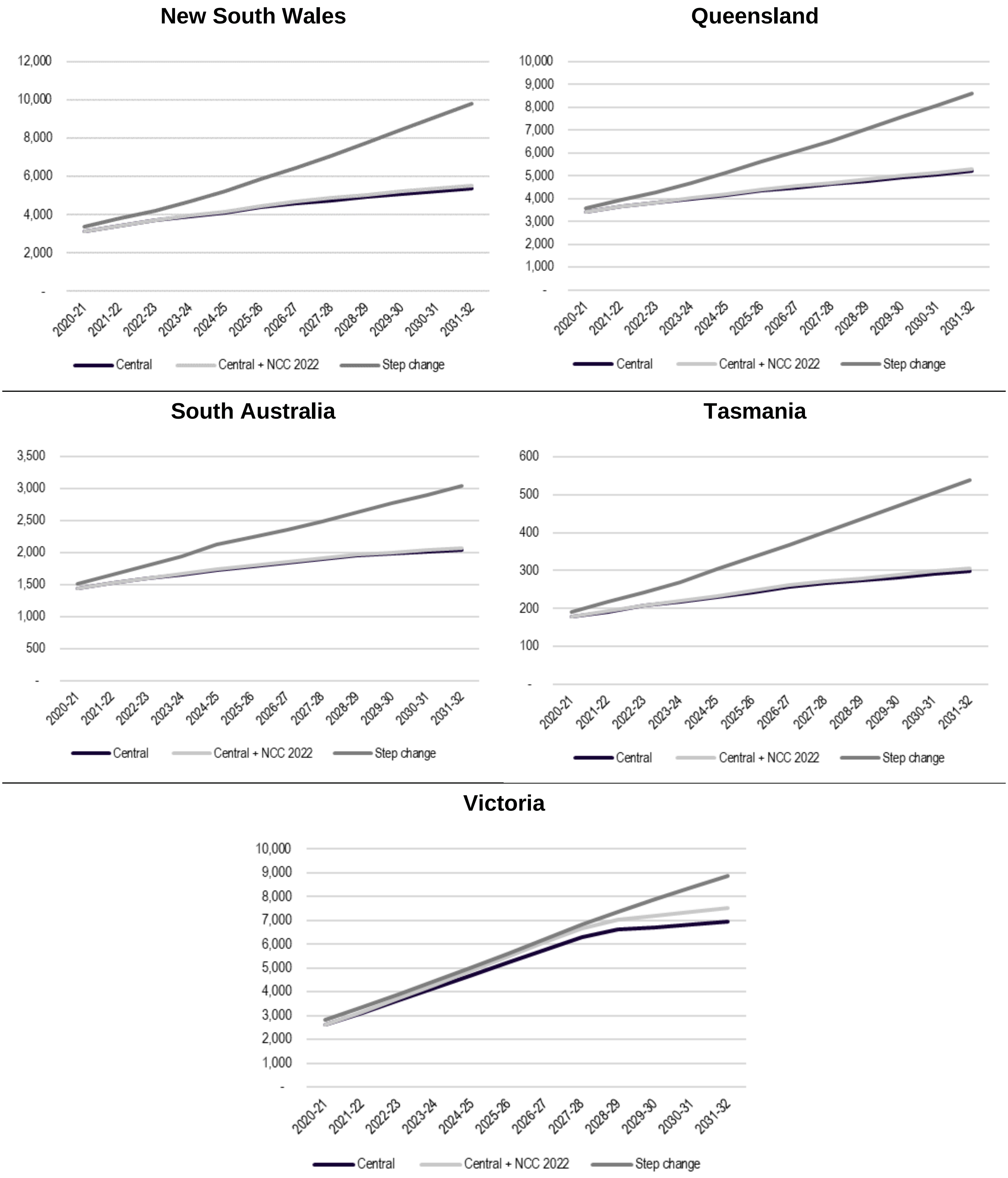
Figure F.7 AEMO's projections of PV installations in Victoria, central scenario



Source: ACIL Allen analysis based on AEMO's Draft 2020-21 Inputs and assumptions workbook

To put the estimated uptake of PV under the NCC 2022 (option A) in perspective, Figure F.8 compares the total PV installations (capacity) under AEMO's central and step change scenarios with the total number under the central scenario plus NCC 2022 (option A). The impact of NCC 2022 (option A) is immaterial in all jurisdictions except Victoria, and in Victoria is immaterial relative to the growth in PV installations.

Figure F.8 Comparison of total PV installations (in MW) under AEMO projections and with NCC 2022 (option A, scenario 1)



Source: ACIL Allen analysis based on AEMO's Draft 2020-21 Inputs and assumptions workbook

F.3 Federal and state energy policies

The Australian Government set an economy-wide target under the Paris Agreement to reduce greenhouse gas emissions between 26 and 28 per cent below 2005 levels by 2030. Australia has stated that it is aiming to overachieve on this target and that it aims to reach net zero as soon as possible, preferably by 2050. Each year, the Government releases economy-wide emissions projections to measure progress towards its 2030 target. Its 2020 projections show that the incremental abatement required in the period 2020-21 to 2029-30 to meet the 2030 commitment is between 56 and 123 Mt CO_2-e (the range reflecting the bounds of 26 to 28 per cent reduction). This represents a 1.0 to 2.3 per cent reduction in projected emissions over the period.[188] This does not include the New South Wales Electricity Infrastructure Roadmap announced in November 2020, which our projections show will enable Australia to achieve the remaining abatement required.

The states and territories have individually announced a target of net-zero emissions by 2050. To achieve their objective, each jurisdiction is implementing its own policies with most focusing their efforts in the electricity sector, which is well understood to provide the most cost-efficient and least challenging abatement opportunities in the short-term, given the available renewable energy technologies.

In 2020, a number of states legislated new renewable energy policies (see Figure F.9). Tasmania legislated ambitious renewable targets of 150 per cent by 2030 and 200 per cent by 2040 (TRET) and New South Wales legislated their Electricity Infrastructure Roadmap (the Roadmap). These are in addition to the Queensland Renewable Energy Target (QRET)[189] and Victorian Renewable Energy Target (VRET) which were already in place.

There has also been a particular focus from the state governments of New South Wales, Queensland and Victoria to support the development of Renewable Energy Zones (REZ) as laid out by AEMO's Integrated System Plan (ISP). The development of these zones will assist them to achieve their renewable energy targets.

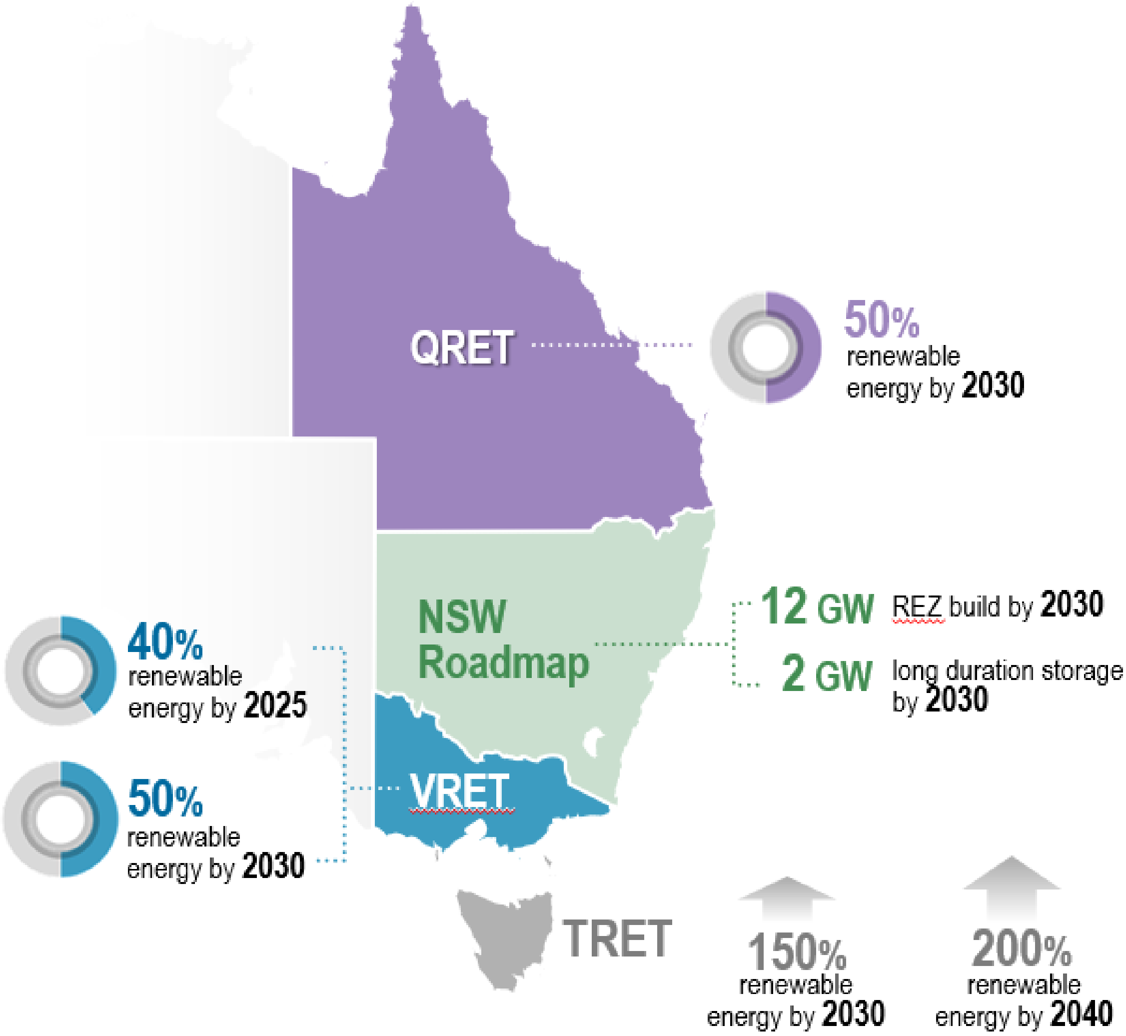
The following section covers the current renewable energy policies which affect the NEM along with a discussion of ACIL Allen's modelling assumptions to implement these policies in our market projection.

The reference case energy policy assumptions for the period post-2030 are detailed in Appendix F.3.2.

[188] This assumes the Government does not make use of overachievement for the previous Kyoto periods.

[189] The QRET at this time is not a legislated target.

Figure F.9 State renewable energy policies included in reference case



Note: South Australia has indicated an ambition of 100% net renewable energy generation by 2030 in their Climate Change Action Plan (2021-2025). However it is not yet clear how the state intends to deliver on this target.
Source: ACIL Allen

F.3.1 Current energy policies

The LRET

The Commonwealth Government's LRET has a direct impact on the electricity sector through the incentives it provides for the development of centralised renewable generation. However, in more recent years, a combination of favourable electricity market conditions and the rapidly declining cost of renewables has encouraged a significant amount of investment in new large-scale wind and solar capacity in the NEM.

The reference case assumes an annual LRET target of 33,000 MWh from 2020 to 2030, which is the current policy. The target has been met and the scheme is now oversubscribed.

In the reference case, the projected price of Large-scale Generation Certificates (LGCs)[190] reduces the short-run marginal cost (SRMC) of all semi-scheduled wind and solar farms.

The NSW Roadmap

The New South Wales Electricity Infrastructure Roadmap (the Roadmap) requires 12,000 MW of renewables to be developed by 2030:

- 8,000 MW in the New England REZ
- 3,000 MW in the Central-West Orana REZ (referred herein as *Central West*), and
- another 1,000 MW in the remaining REZs (South West, Central Tablelands and/or Central Coast).

The Roadmap also requires an additional 2,000 MW of long-duration storage (not including Snowy 2.0) to be built by 2030.

The Roadmap is set out in the *Electricity Infrastructure Investment Act 2020*.

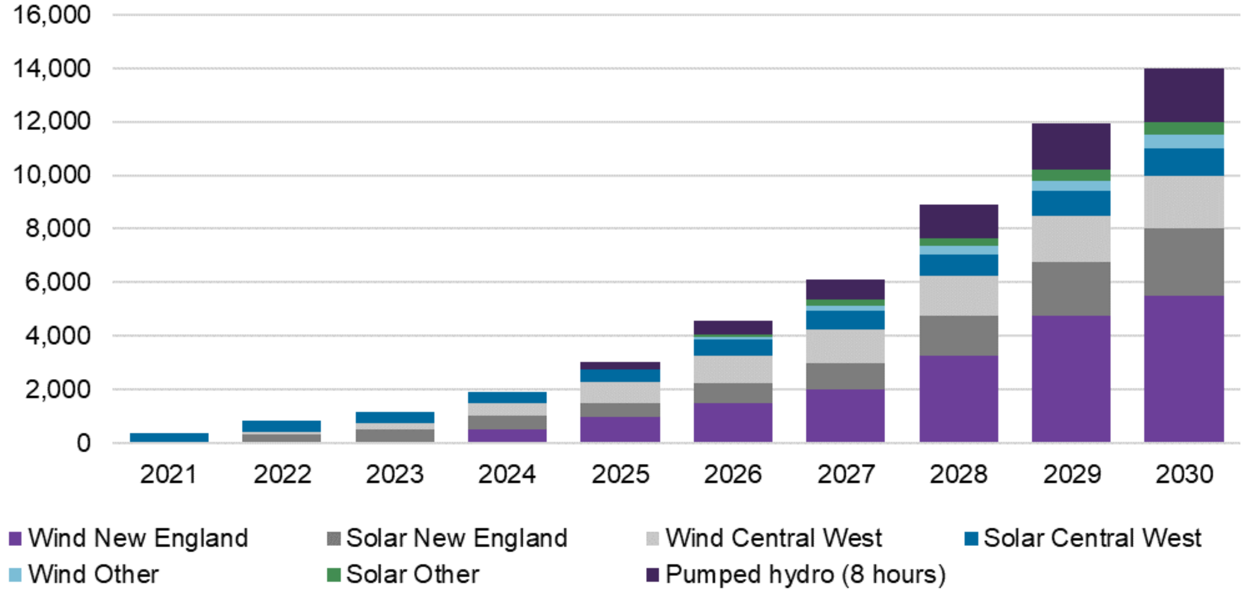
The reference case assumes the Roadmap capacity is added to the market in approximately a straight-line over the period from 2023 through 2027 and is then assumed to ramp up further to 2030 as the New England REZ is fully developed (see Figure F.10). The split between wind and solar technologies is assumed to be two-thirds wind and one-third solar. Our analysis shows that on a commercial basis the greater share of the capacity should be expected to be wind, however the upfront cost for solar technology is lower and it is easier (fewer environmental concerns) and quicker to build than wind.

ACIL Allen has identified a total of 1,034 MW of committed and operational projects which are potentially eligible to form part of the Roadmap. These projects are located in either the New England or Central West REZ and were identified as committed or existing in a generation information page published by AEMO under the National Electricity Rules after 14 November 2019 (per the eligibility requirement outlined in the Act). They are assumed to enter the market between 2021 and 2023 and include:

- Crudine Ridge wind farm (135 MW, Central West)
- Goonumbla solar farm (69 MW, Central West)
- Molong solar farm (36 MW, Central West)
- Nevertire solar farm (105 MW, Central West)
- Wellington solar farm (174 MW, Central West)
- New England solar farm (400 MW, New England)
- Metz solar farm (115 MW, New England).

[190] 1 LGC represents 1 MWh of eligible renewable generation.

Figure F.10 Assumed New South Wales Roadmap capacity, by technology type and REZ (MW)



Source: ACIL Allen

The Queensland RET

There are several initiatives by the Queensland Government under the Powering Queensland Plan including:

— affirming a target of 50 per cent renewable energy in Queensland by 2030 (QRET)

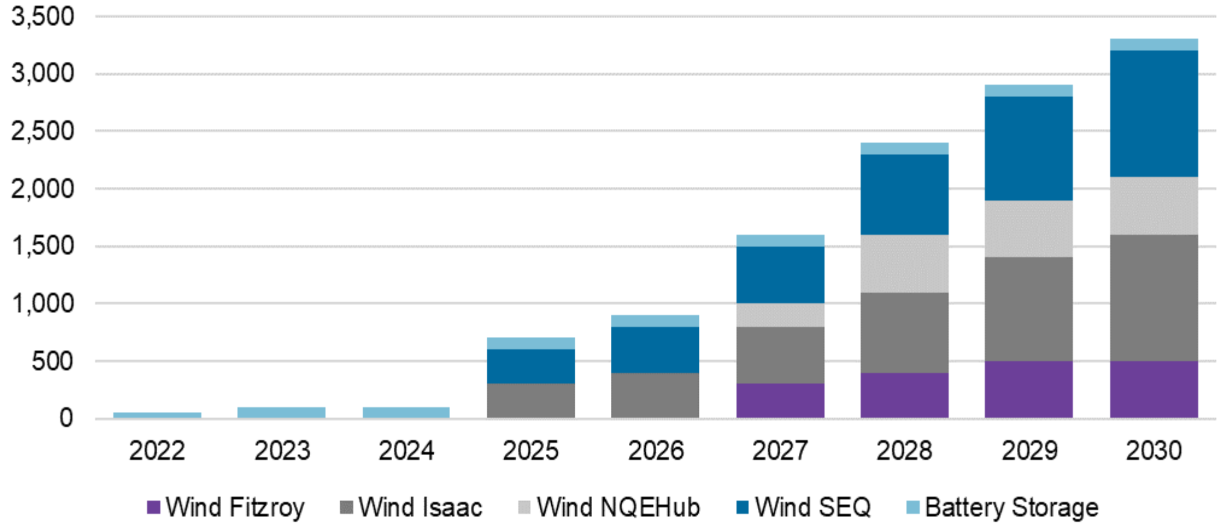
— establishment of CleanCo based around Wivenhoe and Swanbank E (and hydro plant in north Queensland) with the objective of 'firming up' contracted renewable energy and supporting up to 1,000 MW of majority Government owned renewable energy projects. In May 2020, CleanCo committed to:
  – a 400 MW power purchase agreement with the owners of MacIntyre wind farm resulting from the Government's Renewables 400 initiative. CleanCo also announced that it will build its own 100 MW wind farm on the same site.
  – a 320 MW power purchase agreement with the owners of Western Downs solar farm.

ACIL Allen assumes that the CleanCo portfolio will include a further 100 MW of battery storage to compliment these renewable off-take agreements (in line with the original intent of the Renewables 400 reverse auction).

Our analysis shows that a further 3,200 MW of new wind capacity[191] will be required by 2030 to meet the QRET. This capacity is assumed to be added to the market from 2025 such that the State's renewable energy penetration increases approximately linearly to 2030 (see Figure F.11).

[191] ACIL Allen's modelling shows that, given the high uptake of utility-scale solar as well as rooftop PV in Queensland which are cannibalising the wholesale revenues for solar, investment in new utility solar is much less attractive than wind.

Figure F.11 Assumed QRET capacity, by technology type and REZ (MW)



Source: ACIL Allen

The Victorian RET

The Victorian Government has committed to renewable energy generation targets (VRET) of 40 per cent by 2025 and 50 per cent by 2030, which are being met through the Victorian Renewable Energy Auction Scheme (VREAS). The scheme involves establishing power purchase agreements with entrant renewable projects which are allocated through reverse auctions.[192]

For the first round VRET auction, six projects totalling 928 MW of grid-based wind and solar PV projects were announced in September 2018.

In September 2020, the Victorian Government announced it would procure an additional 600 MW of new solar and wind energy capacity through a second VRET auction (VRET2) to make the energy requirements of government operations 100 per cent renewable.

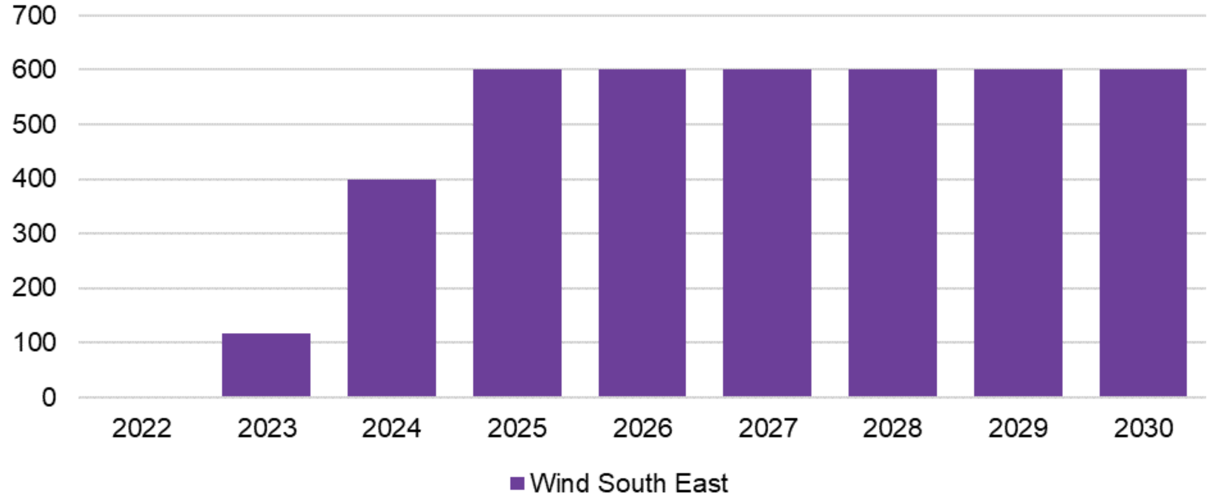
The Victorian Solar Homes Program will also contribute to these targets, increasing the installations of rooftop solar PV in Victoria.

In the reference case, it is assumed the additional 600 MW of new renewable capacity is committed and enters the market by 2025[193] (see Figure F.12). Under the reference case assumptions, this results in the 50 per cent target being met by 2025.

[192] Section 7C in the Federal RET legislation effectively invalidates any state-based scheme which is substantially similar to the Federal scheme. This effectively prohibits the states from employing a certificate-based market scheme to encourage additional renewables. This is a key reason why state governments have preferred power purchase agreements allocated through reverse auctions.

[193] Since the outcomes of VRET2 are not yet known (including technology type and location), ACIL Allen has used the projected market performance of the different technology types in different locations against their build costs to determine the build on a commercial basis. This has resulted in a build of only wind capacity, located in the southeast of the State.

Figure F.12 Assumed VRET2 capacity – by technology type and REZ (MW)



Source: ACIL Allen

The Tasmanian RET

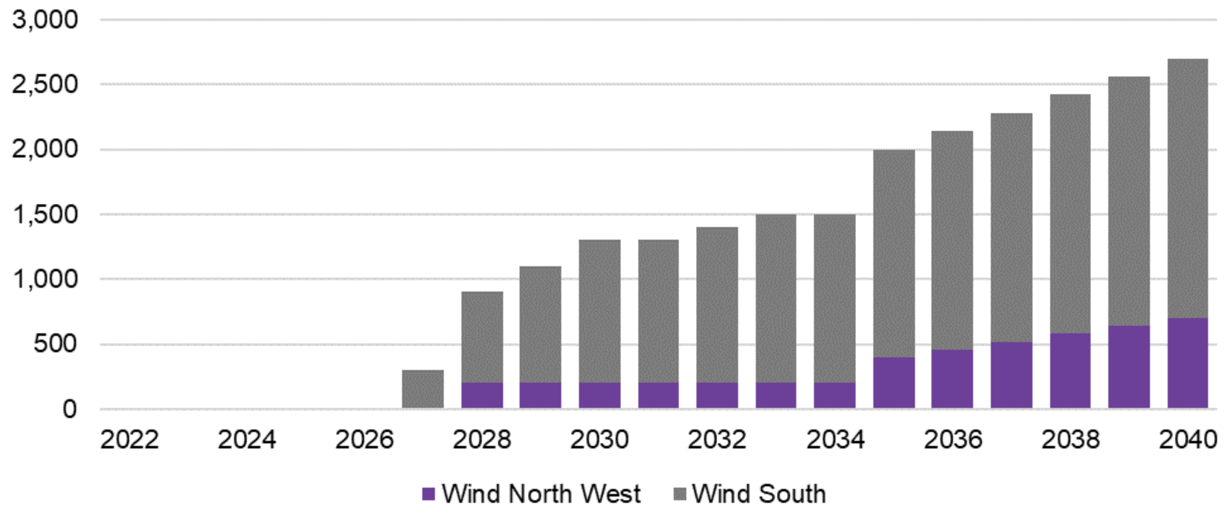
The Tasmanian Government announced the TRET in mid-2020, and passed the required legislation in late 2020. The TRET requires renewable generation equivalent to 150 per cent and 200 per cent of the region's energy requirements by 2030 and 2040, respectively. This equates to an additional 5,250 GWh and 10,500 GWh of annual generation by 2030 and 2040, respectively.

The reference case assumes that the new renewable generation capacity is added to the market in approximately a straight-line over the period from 2027 through 2040 and that most of the TRET will be met by new large-scale wind generation, with a smaller contribution from new rooftop solar PV (see Figure F.13).

The reference case assumes that the targets of 5,250 GWh by 2030 and 10,500 GWh by 2040 are met using *expected* generation outcomes (based on renewable resource) from new renewable capacity in Tasmania.

Our modelling shows, however, that this new build's dispatch will be significantly commercially curtailed, given the flat demand outlook in Tasmania which is already easily supplied by the existing hydro generators. This is in spite of the commissioning of the two Marinus links assumed between 2028 and 2032; without this new interconnection to the mainland, the commercial curtailment of this renewable build would be even greater.

Figure F.13 Assumed TRET capacity – by technology type and REZ (MW)



Source: ACIL Allen

South Australia's 100% net renewable energy ambition

South Australia has indicated an ambition of 100 per cent net renewable energy generation by 2030 in their Climate Change Action Plan (2021-2025). However, it is not yet clear how the state intends to deliver on this target and there has been no indication of potential reverse-style renewable auctions or off-take agreements such as in the other states.

As such, ACIL Allen has not explicitly included the South Australian target in the reference case.

F.3.2 Energy policies beyond 2030

The LRET will end in 2030, and most of the states' renewable energy policies only extend to 2030. It is unclear at this stage what specific action the states may take to reach their respective net zero emissions targets by 2050 and how this will be targeted to different sectors of the economy.

Therefore, ACIL Allen does not assume any further renewable energy state targets post-2030 (except for Tasmania which has legislated its 2040 target). We do however assume that none of the incumbent coal fleet will have the social license to continue their operations through to 2050.

F.4 Generation capacity

ACIL Allen's approach to modelling the NEM's electricity supply is to:

1. incorporate changes to **existing supply** where companies have formally announced the changes – mothballing, closure and change in operating approach
2. include plants that are considered to be **committed projects** (generally once a final investment decision has been reached) as named projects in the model database
3. include additional **capacity requirements to satisfy government policies** (including renewable energy targets assumed in the reference case) as generic entrants

4. include additional **capacity determined to be commercially viable** by the modelling as generic entrants.

Plant closures

With the exception of those plant that are assessed as being committed to close, ACIL Allen assesses the net revenue on a per kW/year basis for each generator (capital return per installed kW after accounting for variable operating and maintenance (O&M) costs and fixed O&M costs).

Where net revenues become negative on a sustained basis, the generator is closed. While this is, in effect, an exercise in perfect foresight which would not be available to plant owners, we consider that, on balance, it is a reasonable approach to modelling likely outcomes.

The O&M cost profiles for major coal-fired power station is not smooth as it is correlated with major maintenance cycles. However, the modelling assumes a smoothed fixed O&M profile for each station in the NEM as ACIL Allen does not have detailed maintenance schedule information. Therefore, the closure of a given generator, as suggested by the modelling, may in practice be brought forward or delayed slightly by the actual timing of major maintenance outages.

The reference case assumes coal-fired generator operation does not extend beyond the end of their technical life (see Table F.3). Life extension of coal-fired generators is considered unlikely given the continued trend in investment in renewable generation and less emissions intensive firming generation. Coal generators are unlikely to have the social license to continue operating in the long-term given the states' net zero emissions targets by 2050.

Owners of coal fired generators have submitted to AEMO an expected closure year as required by the National Electricity Rules (NER). In most cases the expected closure year is within one year of the end of technical life. Owners are required to provide this information, and update it immediately if it is to change, as it affects AEMO's and the network service providers' system planning activities. The reference case assumes coal generators will not operate beyond their expected closure year.

Table F.3 Assumed end of technical life date and expected closure year

Generator	End of technical life date	AEMO expected closure year
Liddell	2022	2023
Vales Point B	2029	2029
Callide B	2028	2028
Gladstone	2029	2035
Yallourn	2032	2028
Eraring	2033	2033
Bayswater	2035	2035
Tarong	2036	2037
Mt Piper	2043	2042
Stanwell	2045	2046

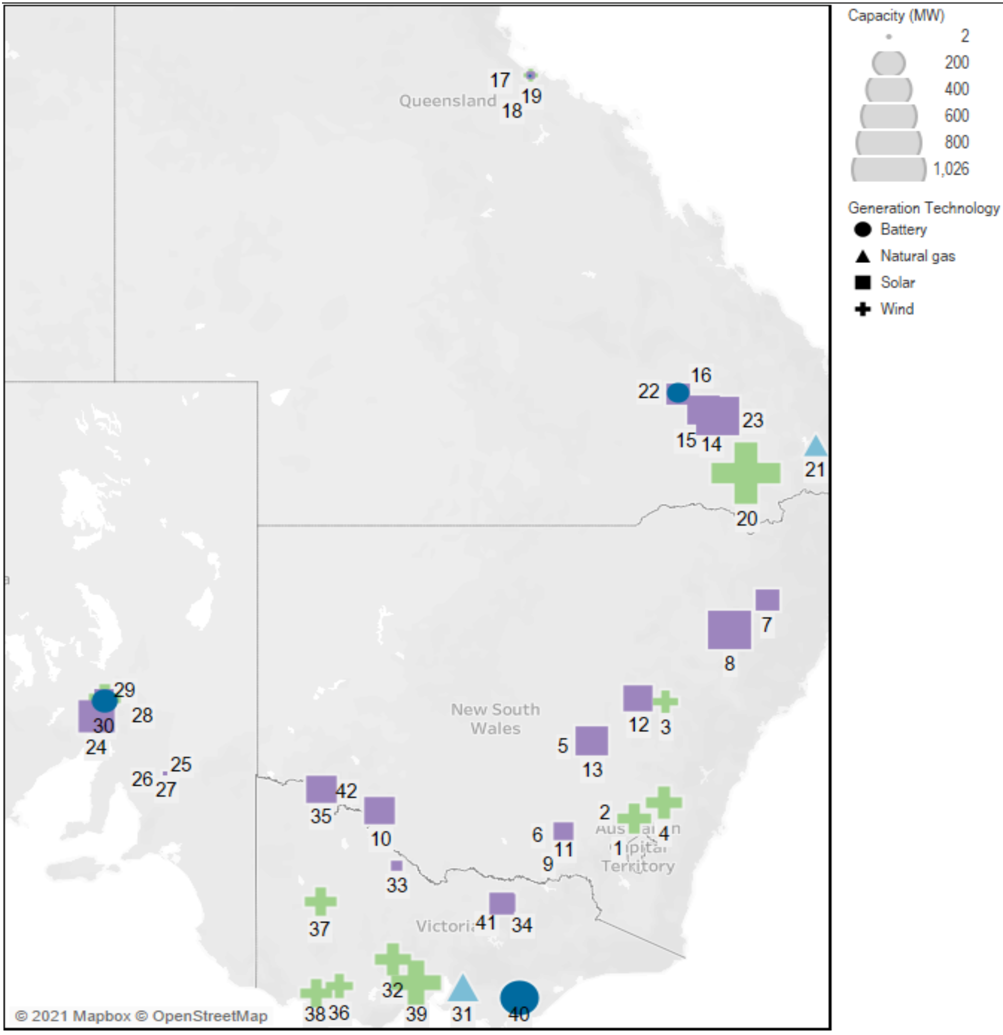
Generator	End of technical life date	AEMO expected closure year
Loy Yang A	2048	2048
Callide C	2051	Unknown
Millmerran	2052	2051
Tarong North	2052	2037
Loy Yang B	2056	2047
Kogan Creek	2057	2042

Source: ACIL Allen, AEMO

F.4.1 New committed supply

Figure F.14 and Table F.4 show the near-term entrants that ACIL Allen considers committed projects and are therefore included in the reference case. These projects have not yet commenced exporting energy to the grid but are expected to come online in the near-term future.

Figure F.14 Near-term addition to supply



Note: See Table F.4 for generator project details per ID number on map.
Source: ACIL Allen

Table F.4 Near-term addition to supply

ID	Region	Name	Generation Technology	Capacity (MW)	First energy exports
1	NSW1	Bango WF	Wind	244	Q4 2021
2	NSW1	Collector WF	Wind	14	Q4 2021
3	NSW1	Crudine Ridge WF	Wind	135	Q3 2021
4	NSW1	Gullen Range WF	Wind	275	Q2 2021
5	NSW1	Jemalong Solar Project	Solar	50	Q2 2021
6	NSW1	Junee Solar Farm	Solar	25	Q2 2021
7	NSW1	Metz Solar Farm	Solar	115	Q1 2022
8	NSW1	New England Solar Farm	Solar	400	Q3 2022
9	NSW1	Sebastopol Solar Farm	Solar	90	Q2 2022
10	NSW1	Sunraysia Solar Farm	Solar	200	Q2 2021
11	NSW1	Wagga North Solar Farm	Solar	30	Q2 2021
12	NSW1	Wellington Solar Farm	Solar	174	Q3 2021
13	NSW1	Wyalong Solar Farm	Solar	240	Q3 2021
14	NSW1	Chinchilla Solar Farm	Solar	182	Q2 2022
15	NSW1	Columboola Solar Farm	Solar	226.8	Q3 2022
16	QLD1	Gangarri Solar Farm	Solar	120	Q3 2021
17	QLD1	Kennedy Energy Park	Battery	2	Q2 2021
18	QLD1	Kennedy Energy Park	Solar	15	Q4 2021
19	QLD1	Kennedy Energy Park	Wind	43	Q2 2021
20	QLD1	Macintyre Wind Farm	Wind	1026	Q2 2022
21	QLD1	Quinbrook AeroGT	Natural gas	132	Q3 2022
22	QLD1	Wandoan South Battery	Battery	100	Q3 2021
23	QLD1	Western Downs Green Power Hub	Solar	400	Q2 2022
24	QLD1	Cultana Solar Farm	Solar	280	Q3 2022
25	QLD1	Morgan-Whyalla Pipeline Pumping Station No 1	Solar	4	Q2 2021
26	QLD1	Morgan-Whyalla Pipeline Pumping Station No 2	Solar	4	Q2 2021
27	QLD1	Morgan-Whyalla Pipeline Pumping Station No 4	Solar	4	Q2 2021
28	SA1	Playford Utility Battery Discharge	Battery	135	Q1 2023

ID	Region	Name	Generation Technology	Capacity (MW)	First energy exports
29	SA1	Port Augusta Renewable Energy Park	Solar	79	Q1 2022
30	SA1	Port Augusta Renewable Energy Park	Wind	210	Q1 2022
31	SA1	APA Dandenong RecipGT	Natural gas	220	Q4 2022
32	SA1	Berrybank WF	Wind	280	Q3 2021
33	SA1	Cohuna Solar Farm	Solar	27	Q2 2021
34	SA1	Glenrowan West Sun Farm	Solar	130	Q2 2021
35	SA1	Kiamal Solar Farm	Solar	200	Q2 2021
36	SA1	Mortlake South WF	Wind	158	Q2 2021
37	TAS1	Murra Warra 2 WF	Wind	209	Q3 2022
38	VIC1	Ryan Corner WF	Wind	218	Q3 2022
39	VIC1	Stockyard Hill WF	Wind	530	Q2 2021
40	VIC1	Victorian Big Battery Discharge	Battery	300	Q3 2021
41	VIC1	Winton Solar Farm	Solar	85	Q4 2021
42	VIC1	Yatpool Solar Farm	Solar	81	Q2 2021

Source: ACIL Allen

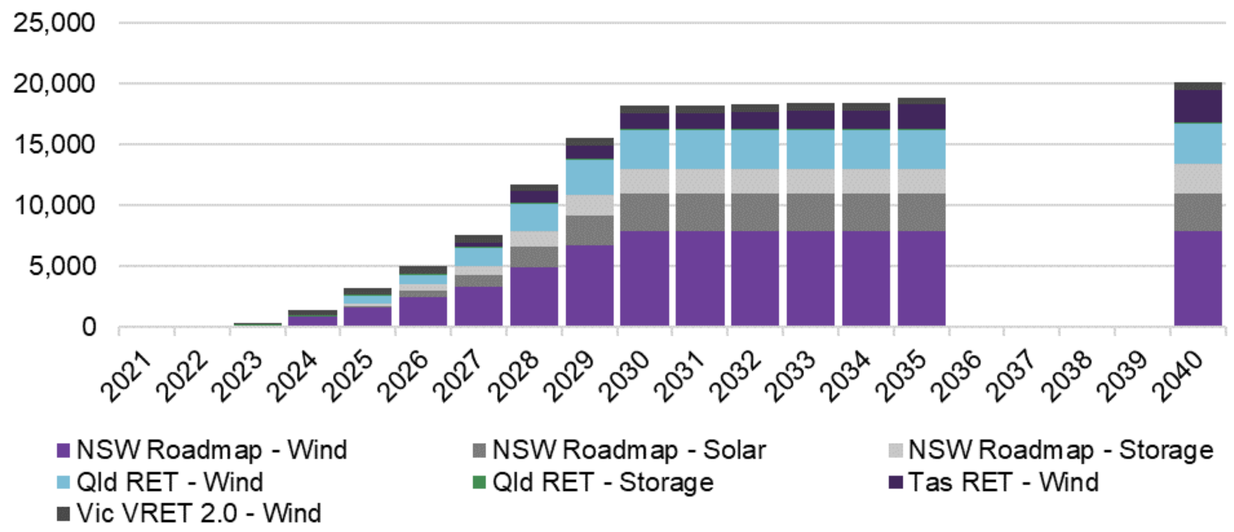
F.4.2 New supply to meet State renewable energy targets

Our analysis shows that the assumed state based renewable energy policies in the reference case will require about 18,000 MW of new investment between 2022 and 2030 as shown in Figure F.15. Although a huge task, about 12,000 MW of renewable capacity has been commissioned in the NEM within the past decade.

Unless specified as part of the relevant policy, the reference case introduces new investment to satisfy each policy on a least cost basis in terms of technology, location and timing.

The projected new investment by state is described in further detail in Appendix F.3.1.

Figure F.15 Projected new investment resulting from assumed state based renewable energy policies (MW)



Note: No state targets assumed beyond 2040.
Source: ACIL Allen

F.4.3 New commercial investment

Beyond the new investment considered as committed to enter the market over the next 12 to 24 months, and the investment required to satisfy government policies, *PowerMark* introduces utility scale new investment in generation capacity based on price signals, rather than using some form of centralised planning criteria.

This approach attempts to mimic the investment decisions made by project proponents. The modelling assumes perfect foresight and introduces the most profitable new entrant, in terms of scale, technology and location, provided that once it is introduced, it meets its required investment return over the long term.

A note on reserve levels

It should be noted that this approach to modelling new entry may result in reserve levels which are below what AEMO might consider to be required to ensure reliability criteria are met. Where this is the case, it is implicitly assumed in the reference case that AEMO utilises its Reserve Trader Role to contract for additional supply and that this supply is offered to the market at the market price cap and therefore only operates when unserved energy is likely to occur. This additional supply therefore does not affect projected market price outcomes.

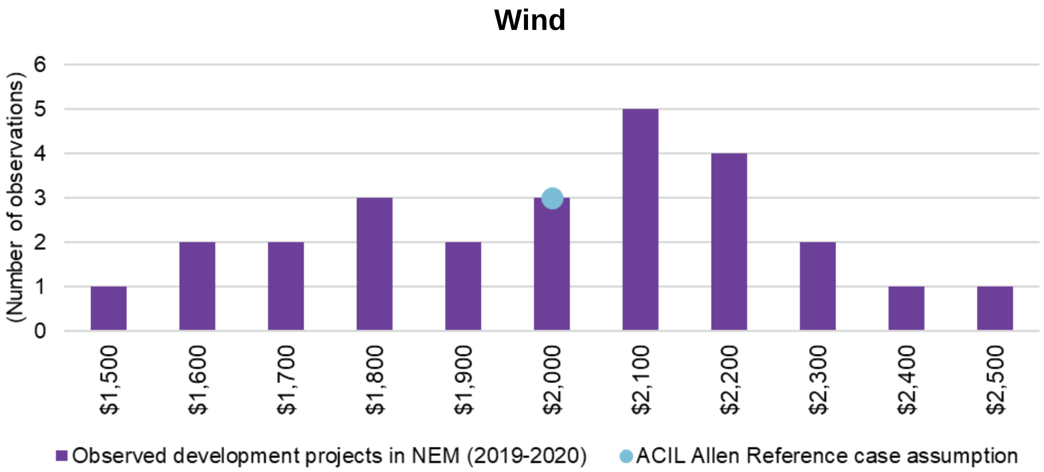
Assumed capital costs of new candidate technologies

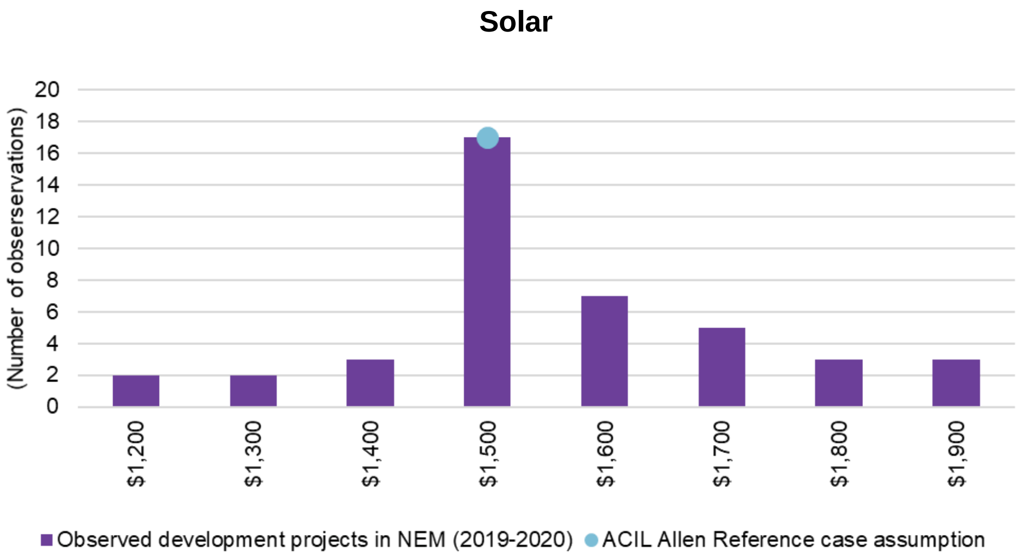
PowerMark includes a number of different technologies as candidates for commercial new investment in the reference case.

The starting points for our capital cost estimates for wind, solar, CCGT and aeroderivative GT technologies are derived from our internal database of observed new entrant projects. Starting capital costs for storage technologies are based on a combination of published sources supplemented with de-sensitised information we have gathered when working for clients on development projects of similar type.

Figure F.16 shows that the starting capital costs assumptions we adopt for the two most dominant new entrant technologies, wind and solar, in the reference case sit close to the mid-point of the distribution of recent development project costs.

Figure F.16 Distribution of observed wind and solar farm capital costs in the NEM ($AUD/kW, real 2021)



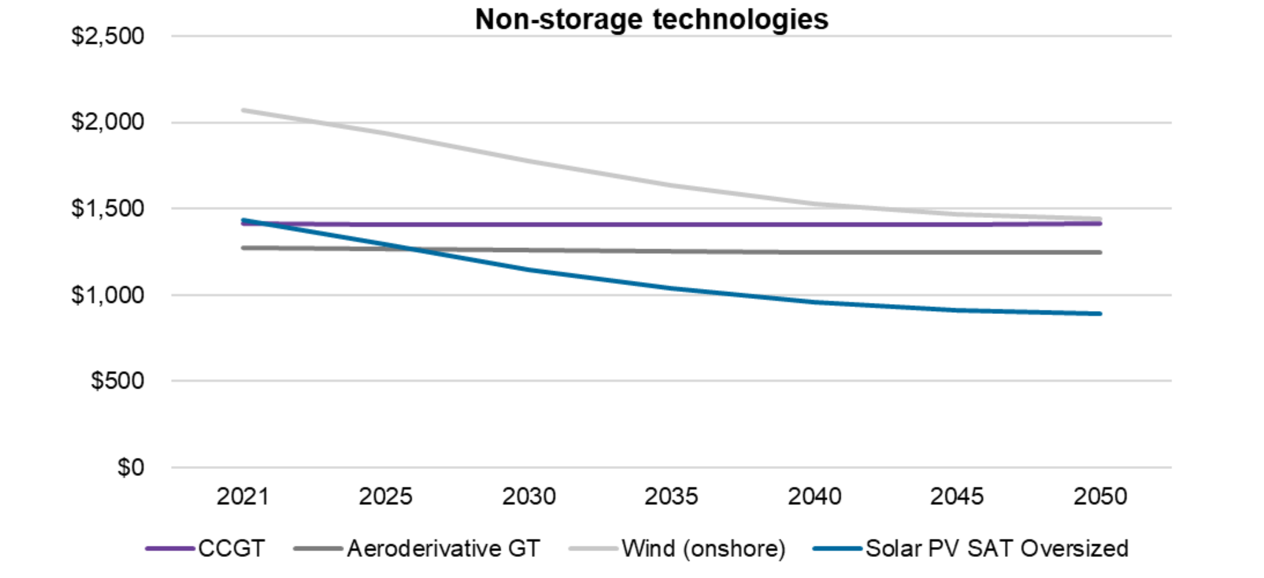


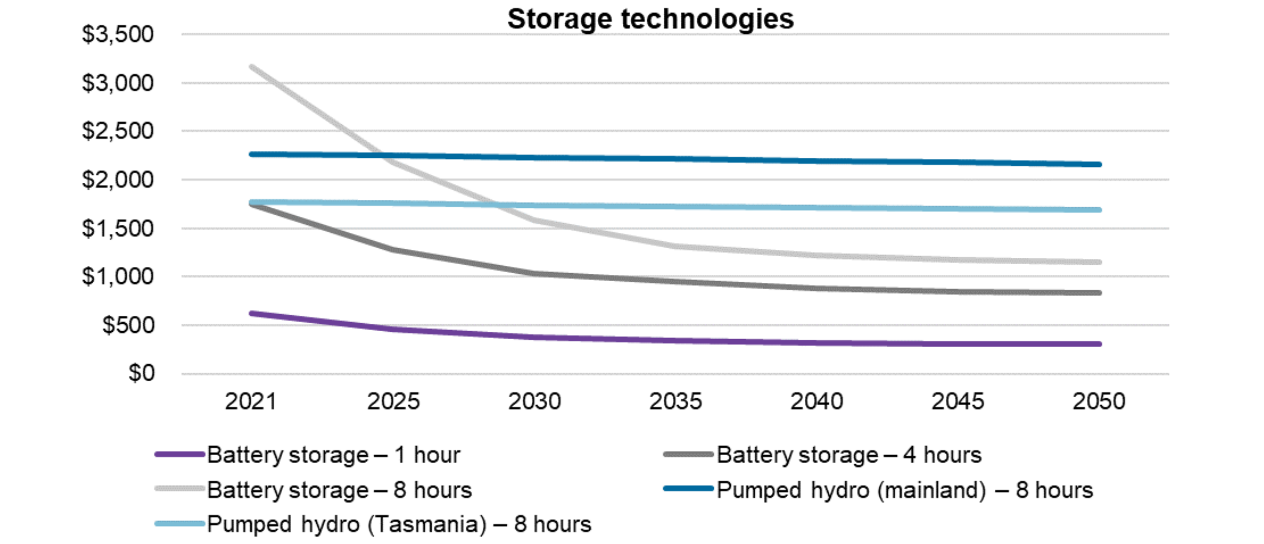
Source: ACIL Allen analysis of public announcements

Figure F.17 summarises the trend in assumed capital costs for non-storage and storage technologies in the reference case. Mature technologies, such as gas fired generators and pumped hydro, are assumed to experience little if any further decline in capital costs. Wind and solar capital costs are assumed to experience a decline of about 20 and 30 per cent respectively between now and 2035, and battery storage costs are assumed to decline by about 50 per cent by 2035.

ACIL Allen maintains a database of cost and technical data for other technologies in addition to those shown above. However, we limit the list of candidate technologies adopted in the modelling to those which are viable under a range of different scenarios.

Figure F.17 Assumed capital costs by new candidate technology and year of commissioning ($AUD/kW, real 2021)





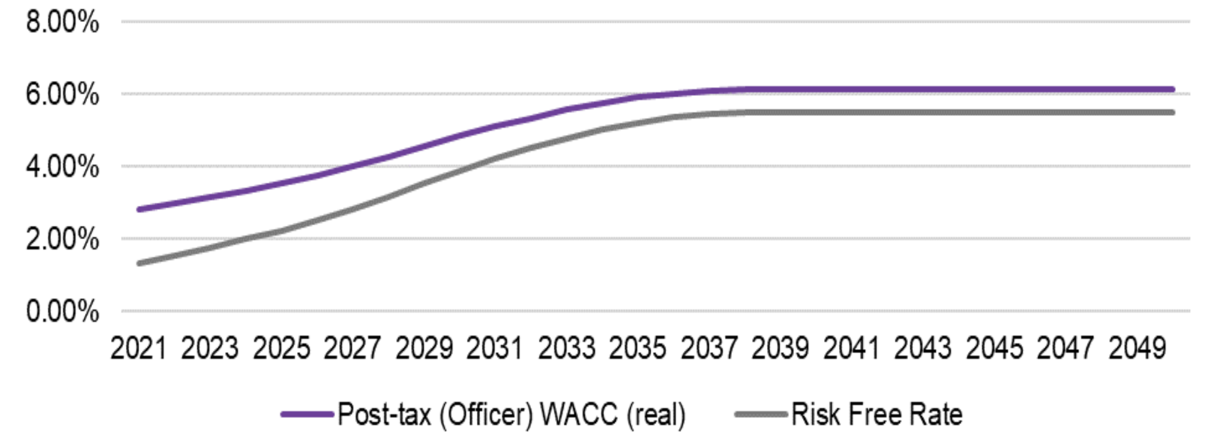
Source: ACIL Allen

Weighted Average Cost of Capital

The required returns for new entrant power generation projects are derived using a discounted cash flow model with a discount factor set at the investment's assumed WACC. We use a standard post tax real officer WACC formulation.

Our estimate of the current post tax real WACC for power generation projects is 2.63 per cent based on the lower current interest rates. The reference case assumes interest rates normalise by the mid-2030s and similarly the WACC recovers to a long-term assumption of 6.13 per cent (see Figure F.18.

Figure F.18 Assumed WACC and risk-free rate (%)



Source: ACIL Allen

Resulting Levelised Cost of Electricity (LCOEs)

ACIL Allen takes the assumed new entrant costs inputs and calculates the **annualised capital costs** of new entrant generation projects in the NEM using a discounted cash flow (DCF). The values are expressed in $ per kW of installed capacity per year. These values are then **added to O&M costs**, to arrive at the **levelised cost of electricity (LCOE)**, which takes into account the volume of generation, or capacity factor, of the given new entrant project.

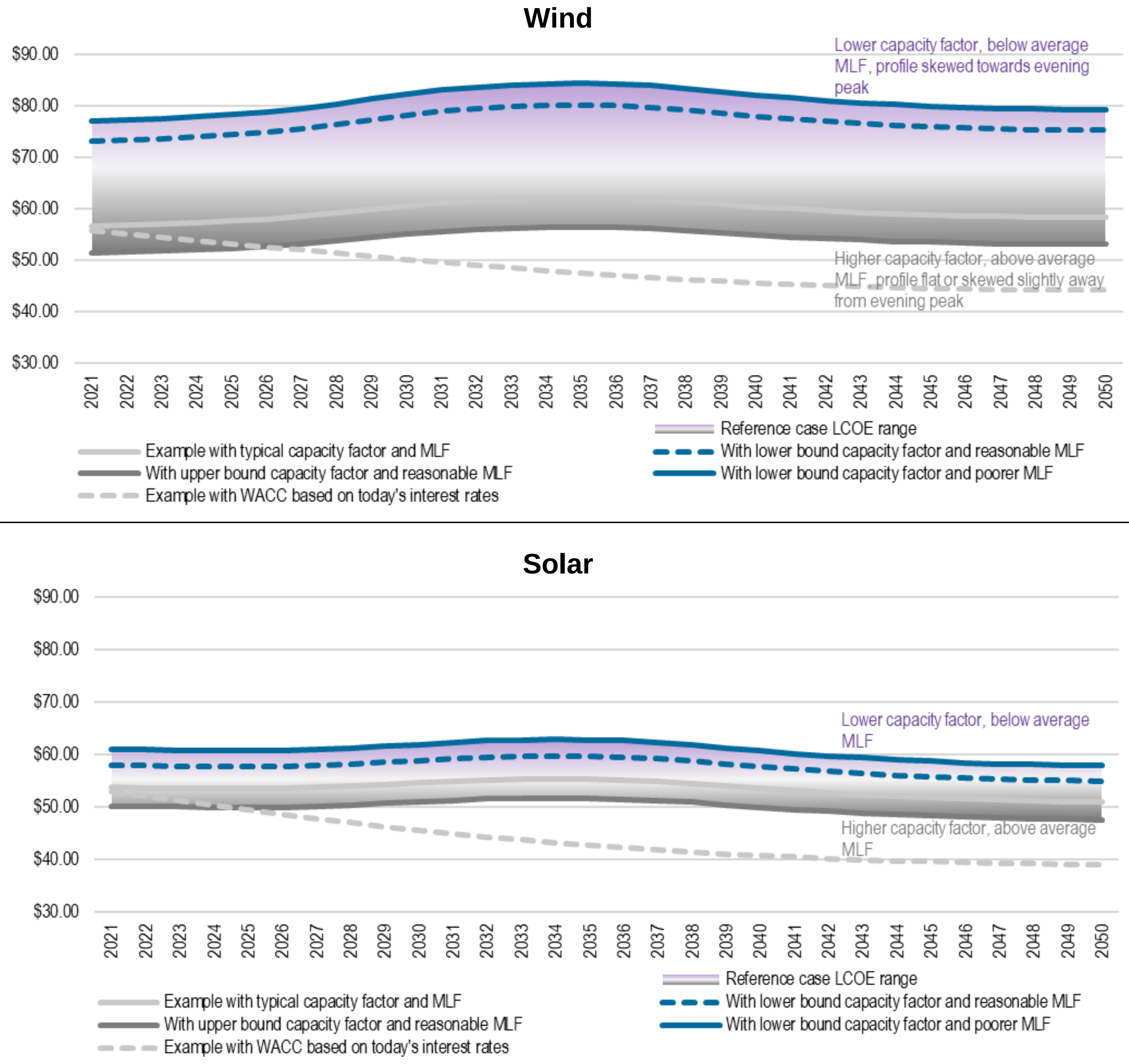
PowerMark's modelling framework uses the **annualised capital costs**, rather than the LCOE, which fluctuates due to variations in capacity factor, when assessing new investment viability.

Figure F.19 shows the assumed LCOEs for wind and solar throughout the projection period. The LCOEs presented in these graphs are measured at the regional refence node, and therefore are inflated to account for auxiliaries (internal usage of electricity) and adjusted (either inflated or deflated) for marginal loss factors (MLFs). The graphs show a range of LCOEs for each technology – this is a function of the range in capacity factors observed in the modelling.

Capacity factors for wind and solar vary across the NEM due to differences in the renewable energy resource (for example, Tasmania has a wind resource that in general results in higher capacity factors than other locations in the NEM), and the extent of curtailment (that is, the extent that the available resource is not dispatched into the NEM for commercial or network limitation reasons[194]).

[194] The PowerMark modelling takes into account commercial curtailment only (except for any assumed curtailment in the short-term due to known network limitations).

Figure F.19 Projected range of LCOE for wind and solar by year of commissioning ($/MWh)



Source: ACIL Allen

Figure F.19 shows that wind farm technology has a much larger range of LCOEs when compared with solar (about 2.5 times the range). This is not surprising, as the wind resource across the NEM is more varied than the solar resource.

This does not necessarily mean that a wind farm project with a low capacity factor will be less attractive than a wind farm with a higher capacity factor. The relative viability of a project will be a function of its:

— **Time of day and seasonal resource profile** – with resources skewed towards the evening peak more viable since they are more likely to benefit from high priced outcomes during the day.

— **Marginal loss factor** – with resources located in favourable parts of the grid, close to load centres, being able to earn a higher revenue per unit of output compared with projects located further from load centres.

— **Capacity factor** – an increase in volume of output per unit of capacity installed increases the revenue earnt for the same capital cost.

LCOEs are assumed to increase slightly between 2021 and 2035, before decreasing slightly between 2035 and 2050. This is primarily a result of an **assumed recovery in interest rates** (and hence, in the weighted average cost of capital) from recent very low levels to more normalised levels over the next decade or so. In other words, the real decline in capital costs is more than offset by an increase in interest rates during this period.

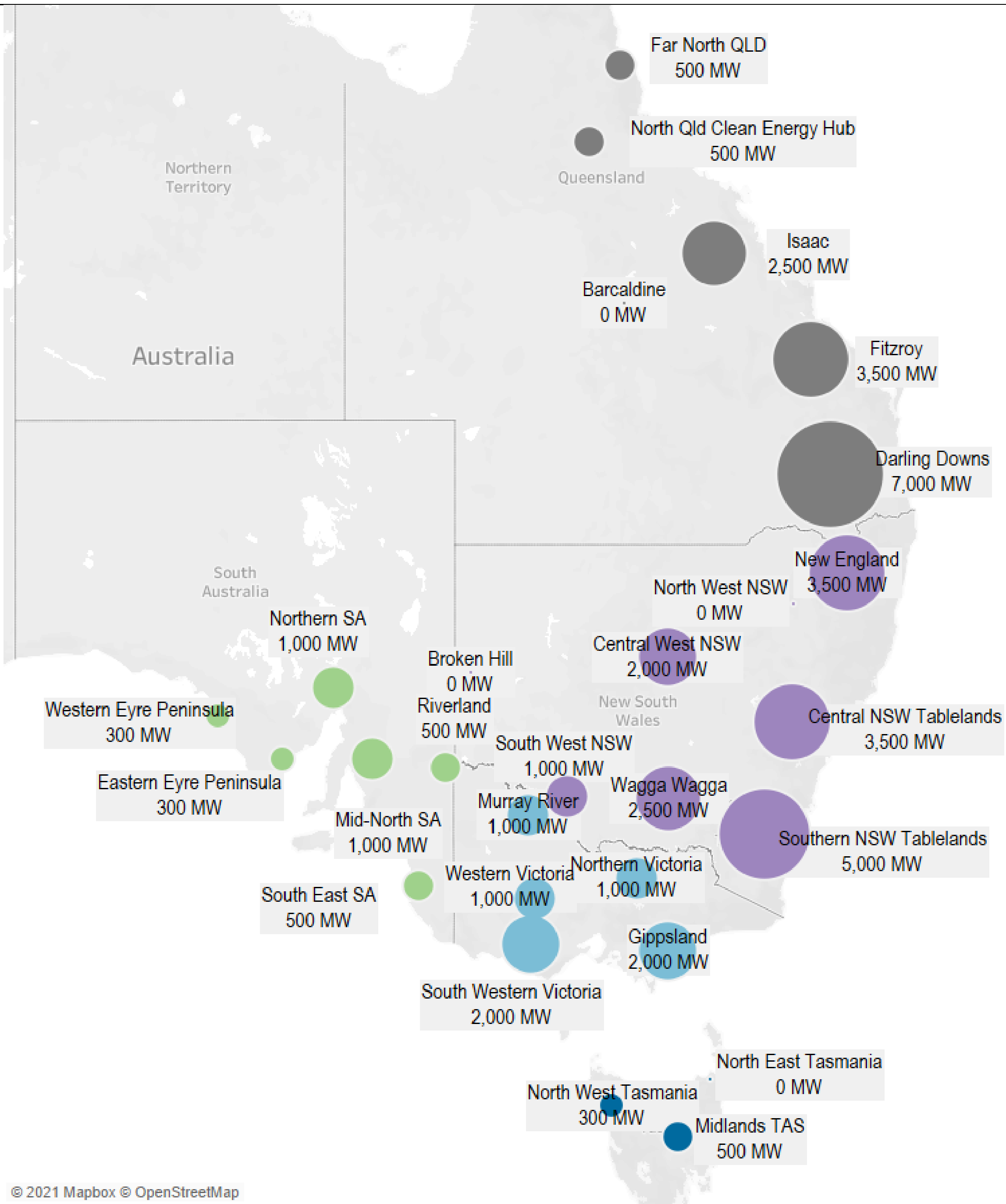
As a point of illustration, Figure F.19 includes the assumed LCOE for an example of a typical project **if interest rates were to remain constant** in real terms throughout the projection period. If interest rates were to remain at today's levels, the LCOE of a typical wind farm project would decrease from about $55/MWh today to about $45/MWh in 2050; and the LCOE of a typical solar farm would decrease from about $55/MWh today to just under $40/MWh by 2050. (The LCOE will not decrease at the same rate as the decline in capital costs since O&M costs are assumed not to decline.)

Build limits

Build limits have been applied for each Renewable Energy Zone (REZ), based on insights resulting from ACIL Allen's MLF modelling (see Figure F.20). Some zones are expected to have small capacity for new build, unless major network upgrades are implemented.

In the long-term, post-2030, ACIL Allen assumes that network upgrades are implemented when large thermal plant close, allowing for new investment build beyond these limits.

Figure F.20 Assumed new investment build limits by renewable energy zone in the period to 2030



Source: ACIL Allen

F.5 Fuel costs

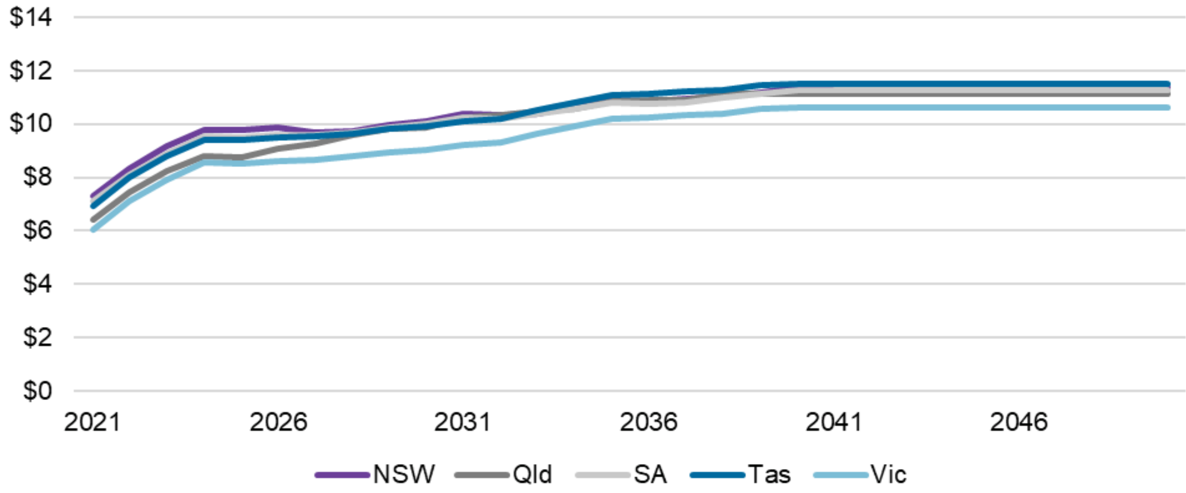
Fuel costs are an important input in a natural gas or coal generator's short-run marginal cost. Other technology types such as wind and solar have zero fuel cost, while pumped hydro and batteries face the cost of recharging at the pool price. The marginal cost of acquiring water for hydro plant is usually zero or close to zero per MWh generated (although they are usually energy constrained and so the water has an opportunity cost i.e., the value of its next best use).

F.5.1 Gas prices

Assumptions regarding the future price of gas used as fuel for electricity generation are drawn from ACIL Allen's February 2021 Eastern Australia Gas Market Projection report, which utilises modelling undertaken with the firm's GasMark model.

Figure F.21 shows the modelled wholesale prices for gas delivered to representative nodes in each region of Eastern Australia under the reference case assumptions for a gas fired combine cycle gas turbine (CCGT). The prices are inclusive of high-pressure gas transmission charges. Prices delivered into peaking plant have a $2/GJ premium added to account for the intermittency of their consumption.

Figure F.21 Assumed wholesale gas prices ($/GJ, real 2021)



Source: ACIL Allen's February 2021 Eastern Australia Gas Market Projection report

In the short-term:

— Wholesale gas prices are expected to **hover between $6-8/GJ** and begin to edge above $8/GJ from 2022 in some southern markets. Before the impact of COVID-19 in the first and second quarters of 2020, domestic prices had softened over the second half of 2019 mainly due to improved supply performance from CSG fields in Queensland and reduced international LNG export prices.

— With global oil and LNG demand recovering quicker than initially anticipated, international LNG prices are projected to rebound to higher levels which will have flow on effects for how much LNG exporters deliver to the domestic market.

In the medium-term:

— Gas prices are projected to return to pre-COVID levels by the mid-2020s as domestic demand and LNG export markets recover, once again placing pressure on supply.

— From the mid-2020s through to the early-2030s, ACIL Allen expects domestic gas prices to then remain relatively stable, **averaging between $8-10/GJ**. This assumes the following additional supply to come online:

  – Incremental supply from projects in the Gippsland Basin and the Otway Basin (and some brownfield development in the Gippsland)

- The development of an LNG import terminal. ACIL Allen anticipates the Port Kembla terminal to now be the first LNG terminal likely to be built with first gas online by 2023.
- The Narrabri Gas Project by Santos and the Surat Gas Project by Arrow Energy, assumed to reach full production in late 2020s and mid- to late-2020s, respectively.

In the long-term, gas prices are projected to increase gradually in real terms through to the end of the projection period, **reaching levels of around $11/GJ**. The fundamentals of declining reserves from mature gas producing regions and weak long-term investment in supply beyond current projects in feasibility is the major reason for escalating gas prices.

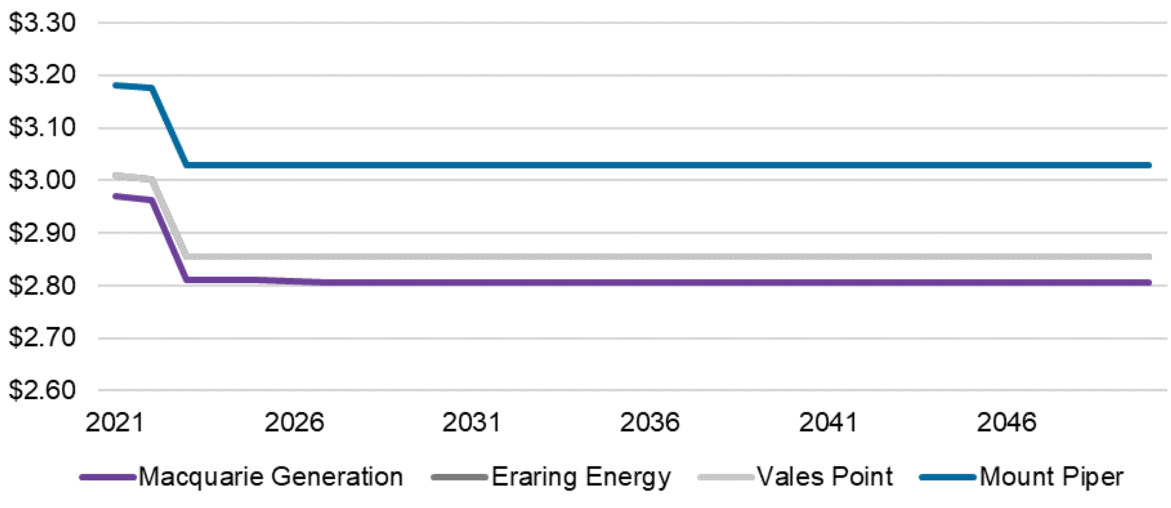
F.5.2 Coal prices

In this report the price of coal for power generation refers to the marginal price of coal.

NSW black coal generators

The delivered marginal coal prices into the NSW coal power stations are assumed to be linked to export parity and therefore follow the assumed movement in export coal prices (see Figure F.22). Eraring and Vales Point are assumed to have the same coal prices. Of the NSW generators, Mt Piper is assumed to incur the highest coal price as it is expected to obtain its supply from the higher cost northern western fields once its current supply from the Springvale mine ceases in the mid-2020s.

Figure F.22 Assumed coal price into NSW stations ($/GJ, real 2021)

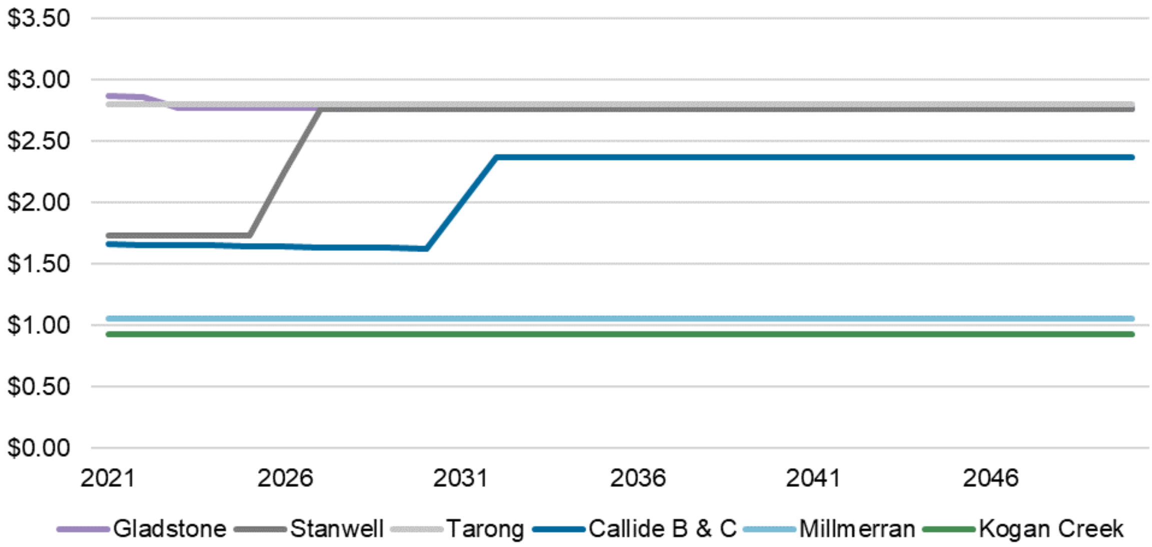


Source: ACIL Allen

Queensland black coal generators

Where domestic prices are exposed to the export coal price, coal prices are similar in Queensland and NSW. However, there is a significant volume of coal from captive mines in Queensland which has noticeably lower prices (see Figure F.23).

Figure F.23 Assumed coal price into Queensland stations ($/GJ, real 2021)



Source: ACIL Allen

In Queensland there are four types of coal supply arrangement.

Mine mouth – own mine

Power stations in Queensland relying on their own mine mouth coal supply are least likely to be affected by export prices and it has been assumed that they will offer marginal fuel costs into the market. They are Tarong, Tarong North, Kogan Creek and Millmerran.

Mine mouth – captive third-party mine

Callide B and Callide C are power stations with a mine mouth operation with a third-party supplier and are therefore likely to be under pressure to accept higher prices more in line with export parity particularly with price reviews and contract renewal.

Transported from captive third-party mine

Stanwell power station has been in a long-term supply arrangement with the Curragh mine since 2004. In 2018-19, Stanwell signed a new supply agreement which will extend its coal supply to 2038. We have assumed that Stanwell will move to an export parity arrangement which is an imputation of the coal netback price when the current arrangement expires in the late 2020s.

Transported from third-party mine

Gladstone which relies on transported coal from third party mines is most exposed to pass through of export prices. The Callide Boundary Hill mine is the lowest cost potential supplier of coal into Gladstone as this coal has poor yield for export. It is assumed that Gladstone moves to an arrangement where half its future coal supply will be at prices at export parity and half from the lower cost Callide mine.

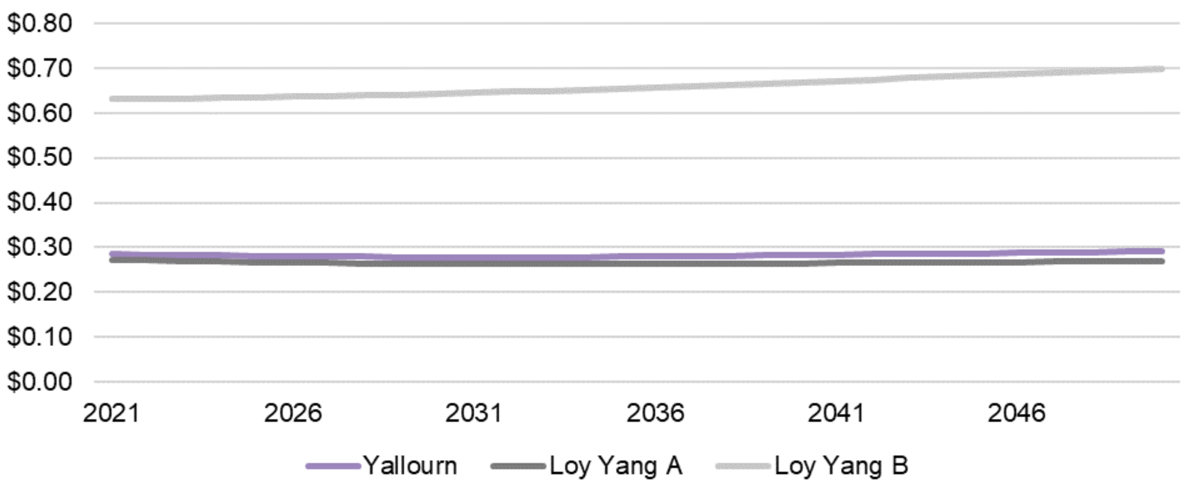
Victorian brown coal generators

Coal mined for power generation in Victoria is not suitable for export and hence not affected by fluctuations in export prices. Extensive deposits of brown coal occur in the tertiary sedimentary basins of the Latrobe Valley coalfield which contains some of the thickest brown coal seams in the world.

Mine mouth dedicated coalmines supply all the power stations. The coalmines are owned by the same entities that own the power stations with one exception: the Loy Yang B power station is supplied by the adjacent Loy Yang Power mine (owned by the owners of the nearby Loy Yang A power station) under a coal supply agreement which expires around 2050.

The marginal price of coal for the Victorian power stations is generally taken as the marginal cash costs of mining the coal (see Figure F.24).

Figure F.24 Projected coal price into Victorian stations ($/GJ, real 2021)



Source: ACIL Allen

F.6 Interconnectors

Interconnectors can either be a source of lower priced electricity coming into a region, or a means to export surplus capacity. A summary of the interconnectors and interconnector expansions assumed in the reference case is shown in Table F.5.

F.6.1 Existing interconnectors

This section details the modelling assumptions of existing interconnectors in the NEM.

Assumed capacity

Interregional interconnection capacity assumed in the reference case considers limitations of the transmission system. For this reason, the assumed interconnector capacities may well be less than the capacity of the physical interconnectors.

For example, the total of the physical interconnector capacity between NSW and Queensland is about 1,000 MW – but the location of the interconnectors and the constraints of the NSW grid limits the flow of generation from the Hunter Valley region in NSW to Queensland such that the effective capacity of the NSW to Queensland interconnection is about 600 MW, reducing even further during peak and shoulder periods.

The Basslink interconnector

It is important to mention the difference in operation of the Basslink interconnector compared to other interconnectors in the NEM. Basslink is set in PowerMark as an entrepreneurial interconnector linking Tasmania to Victoria.

Basslink is owned and operated by Keppel Infrastructure Trust. Hydro Tasmania pays an annual facilitation fee for the exclusive right to offer Basslink capacity to the market and receives all spot market revenues (interregional settlements residues). In response to competition concerns, the Tasmanian Government has imposed restrictions on Hydro Tasmania requiring all import capacity to be offered at zero dollars (but for exceptional circumstances) and a prohibition on offering negative prices in either direction.

Therefore, it is bid in a way that attempts to maximise the net revenue of the Hydro Tasmania assets but at the same time accounting for the energy constrained capacity in Tasmania.

Temporary constraints

The reference case includes temporary constraints on the interconnectors. These temporary constraints are related to planned outages as part of upgrades, damage to transmission infrastructure, but also due to the recent challenges of power system security. The derating of the interconnector capacity has been informed by market notices, as well as historical data on interconnector flows.

The temporary constraints that have been included in the reference case are as follows:

- Constraints on the **QNI interconnector from March-May 2021** during daytime hours as part of planned outages for further upgrades. During these periods, the QNI interconnector capacity is derated from 1100 MW to 400 MW in the direction Queensland to New South Wales.
- Constraint on the **Heywood interconnector until June 2021** due to damage on the transmission infrastructure. During this period, the Heywood interconnector capacity is derated from 460 MW to 400 MW in the direction from Victoria to South Australia and is derated from 500 MW to 420 MW in the direction from South Australia to Victoria.

F.6.2 New interconnectors and upgrades

All of the interconnector upgrades assumed in the reference case are included in AEMO's 2020 ISP list of "actionable projects". The one exception is the QNI Medium upgrade which is considered by AEMO to be part of the ISP's optimal development path.

AEMO stated in their ISP report (published before the legislation of the NSW Electricity Infrastructure Investment Act) that should the New England REZ development be accelerated through NSW government policy, then it could be expected that works for the NSW side of the interconnector projects such as the QNI Medium could be brought forward as part of the REZ development.

ACIL Allen's own modelling shows that, without an upgrade to the QNI following the deployment of the NSW Roadmap's 12,000 MW of renewable capacity, a non-negligible volume of renewable generation would be commercially curtailed in New South Wales. Given AEMO's comments and ACIL Allen's own findings, it is reasonable to assume that the QNI Medium development would occur to allow increased resource sharing between NSW and Queensland (noting that the current total transfer capability from NSW to Queensland is limited to about 450 MW).

The Victorian Big Battery

Before the summer of 2021-22, the capacity of the interconnector between Victoria and New South Wales will be expanded for certain periods of the day. The Victorian Government requested AEMO to undertake a procurement process for a System Integrity Protection Scheme (SIPS) for the Victoria to New South Wales Interconnector. In November 2020 it was announced that Neoen had won the tender to build and operate the 300 MW/450 MWh battery (the "Big Battery") to be installed at the Moorabool Terminal Station in the Geelong region. The battery will provide a service allowing an additional flow of up to 250 MW at peak times across the Victoria-New South Wales interconnector (VNI) from New South Wales to Victoria from late 2021.

It is assumed that in summer months (November to March) the battery provides the SIPS service such that the interconnector capacity is expanded by 250 MW when the price differential between the two regions exceeds $100 / MWh. For the remainder of the year, the battery is assumed to operate commercially in the NEM. This SIPS service is assumed to be available for ten years.

Table F.5 Assumed interconnector capacity

Interconnector	Forward direction	Year	Capacity (MW)
VNI	Vic to NSW	2021	900 (590[a])
		Sep 2022 (VNI Minor)	1,070 (590[a])
Heywood	Vic to SA	2021	460 (500)
		Jul 2024	560 (600)
Murraylink	Vic to SA	2021	220 (180)
Basslink	Tas to Vic	2021	594 (478)
QNI	NSW to Qld	2021	450 (1,100)
		Sep 2022 (QNI Minor)	600 (1,290)
		Jul 2032 (QNI Medium)	1,432 (2,050)
Terranora	NSW to Qld	2021	50 (150)
EnergyConnect	NSW to SA	Jul 2024	800 (800)
VNI West	Vic to NSW	Jul 2026	1,930 (1,800)
Marinus Link	Tas to Vic	Jul 2028 (first link)	750 (750)
		Jul 2032 (second link)	1,500 (1,500)

[a] This is expanded by 250 MW when the SIPS service is operational in summer months (assumed to occur when the price differential between the regions exceeds $100/MWh).

Note: Forward capability, with backward capability shown in brackets.

Source: ACIL Allen analysis of AEMO data

Wholesale electricity market modelling – demand assumptions

G

In simple terms, electricity consumption (and peak demand) can be thought of as having the following key components:

1. industrial demand (including energy intensive mining, smelting, LNG extraction and other industrial processes)
2. business or commercial demand (including less energy intensive manufacturing, small and medium businesses)
3. residential demand.

These components describe what we refer to as the *underlying* demand and is influenced by changes in:

— economic and broader market conditions
— price of electricity
— population growth
— adoption of energy efficiency measures.

Each of these components has its own degree of uncertainty. This makes projecting demand for electricity a challenging exercise, as demonstrated by the regularly updated demand forecasts produced by AEMO.

The following pages detail how the electricity demand met by the generators in the NEM is modelled in the Reference case, including the impacts of behind-the-meter technologies (rooftop solar PV, battery storage and electric vehicles).

G.1 The demand modelled in PowerMark

PowerMark models the segment of the market to be satisfied by the NEM, that is, by scheduled and semi-scheduled generation. This is the underlying demand less rooftop PV output, plus electric vehicle charging requirements and behind-the-meter storage round trip losses.

PowerMark is run at the hourly resolution level[195] to produce the Reference case. This requires an hourly operational demand trace for each region and year of the projection period. The key inputs used by ACIL Allen to produce an hourly demand trace are:

1. An underlying hourly demand trace applicable for the beginning of the projection period
2. Parameters to grow the underlying demand trace for each year of the projection period
3. Hourly rooftop PV, behind-the-meter BESS, and EV charging traces applicable for the beginning of the projection period
4. Parameters to grow the rooftop PV, behind-the-meter BESS, and EV charging traces for each year of the projection period
5. Consideration of any step changes in demand that may not be contemplated in the demand forecast parameters, such as the closure of an aluminium smelter or other industrial load.

G.2 Standardised underlying hourly demand traces for start of projection

It is possible to use the set of actual hourly electricity demands for any of the past recent years and then grow this set to the annual demand projection parameters. However, since demand is affected by weather, the risk of using this approach is to wrongly assume that the weather of the chosen past year is typical and will continue in future years.

Instead of making this assumption, the approach used in creating a set of hourly underlying demands attempts to remove atypical weather effects to produce a demand profile that could be expected given a typical weather pattern.

The simulated hourly demand profile for each region is based on actual underlying hourly demand observations for the previous four years and temperature data dating back to 1970-71. The underlying demands are created by taking the actual operational demands

and adjusting for known rooftop PV, BESS and EV uptake. The datasets are used, along with a matching algorithm, to produce multiple sets of weather related underlying hourly demand profiles, from which a single standardised profile is selected.

G.3 Underlying demand projection parameters

A key input in producing the demand trace is the set of annual energy requirements and summer/winter peak demand parameters. Peak demand is the maximum instantaneous demand for electricity placed on the system over a given period, measured in MegaWatts (MW). Energy is the amount of electricity scheduled in the system during a given period, measured in Gigawatt hours (GWh) or Megawatt hours (MWh). These two inputs broadly describe the energy consumption of the NEM.

[195] It can also simulate the NEM at the half-hourly level.

The Reference case makes use of the latest energy and peak forecast produced by AEMO – specifically the forecast based on the medium economic outlook and normal weather conditions (also referred to as the 50 per cent probability of exceedance or P50 peak demand case). This is done by taking the operational demand parameters from the AEMO projection and then adjusting for AEMO's assumed uptake of rooftop PV, BESS and EVs to arrive at a set of underlying demand projection parameters.[196]

Growing the standardised underlying demand traces for each year

The set of standardised underlying hourly demands is scaled for each year of the projection based on the projected underlying demand parameters using a non-linear transformation method.

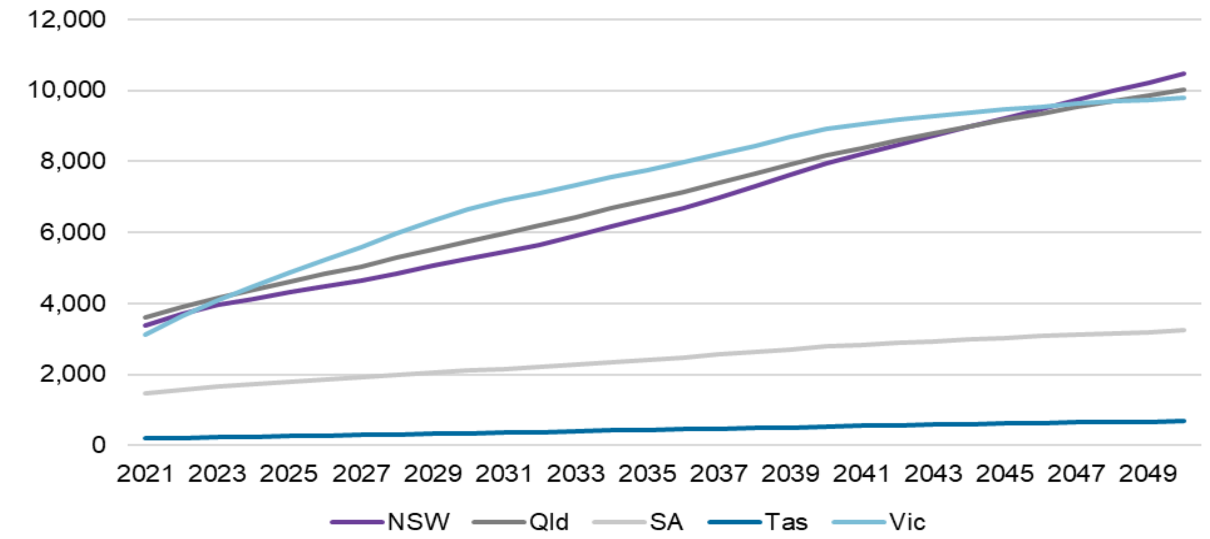
The outcome of this process is a set of underlying hourly demand values that could be expected given typical weather conditions and the projected growth in demand.

G.4 Projection of rooftop PV uptake

ACIL Allen's projections for uptake of rooftop PV systems, shown in Figure G.1, are a function of payback periods for residential and business customers taking into consideration the number of suitable dwellings, roof-space and saturation levels. Inputs for the uptake model consist of system costs, retail electricity prices and government feed-in-tariffs and upfront subsidies.

NEM-wide, installed capacity is projected to grow from about 11,800 MW in 2021 to about 20,000 MW by 2030.

Figure G.1 Projected cumulative installed rooftop PV capacity by region (MW)

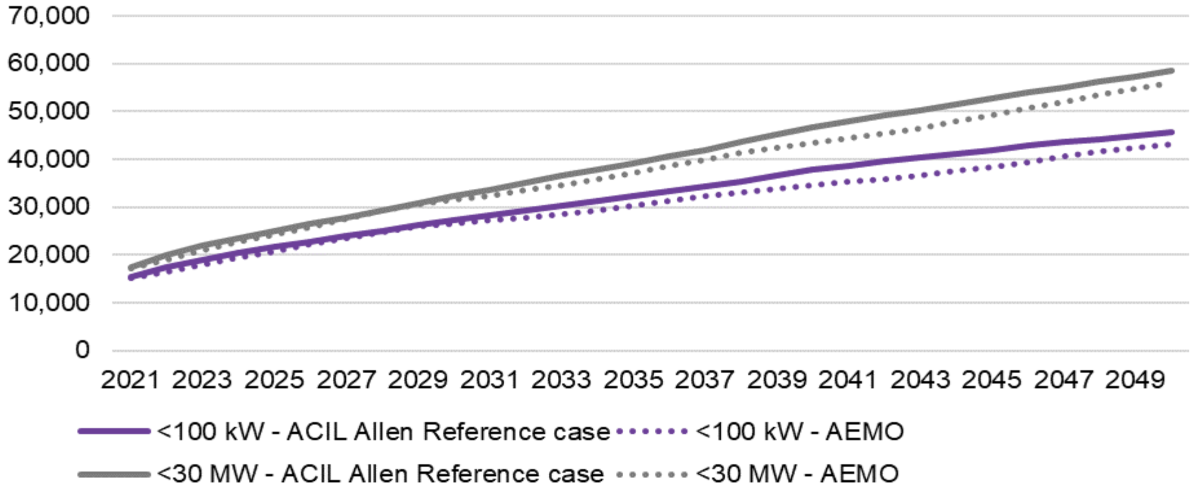


Note: Installations less than 100 kW.
Source: ACIL Allen

[196] ACIL Allen also deducts an estimate of significant non-scheduled generation from the operational demand parameter to arrive at a scheduled and semi-scheduled parameter (the segment of the market supplied by the NEM).

Figure G.2 compares the NEM-wide projected generation of rooftop PV in the reference case with AEMO's latest projection. The projected generation in the Reference case and AEMO's projection are similar up to 2030. After 2030 the projected uptake of rooftop solar in the Reference case diverges to be about six per cent higher than AEMO, which likely relates to differences in long term projected retail price outcomes (noting that we use our own retail price projections which are internally consistent with the Reference case wholesale price projection).

Figure G.2 Comparison of NEM-wide projected rooftop PV generation (GWh)



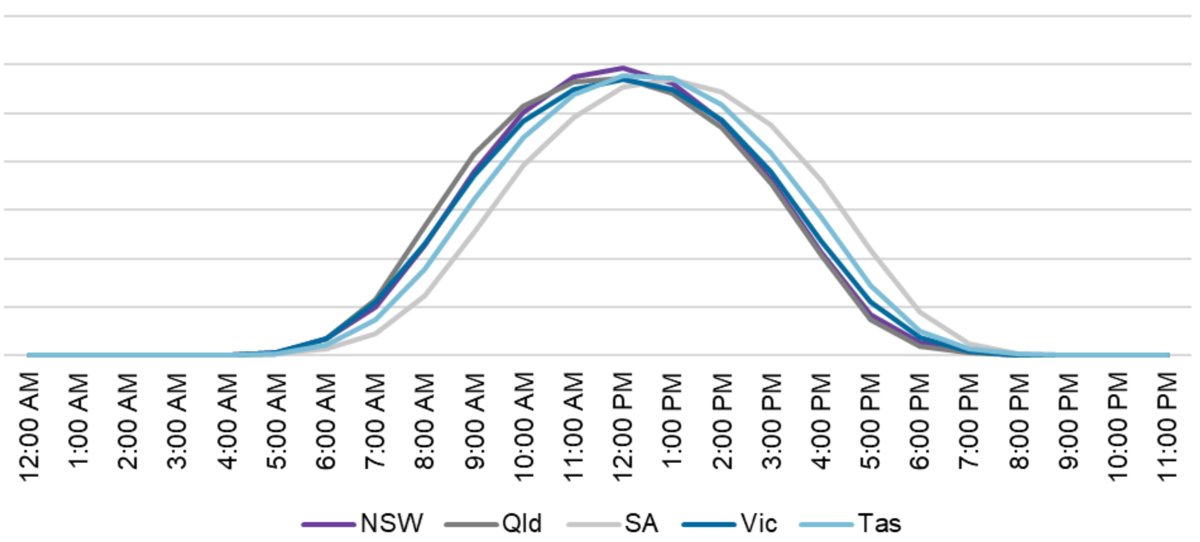
Source: ACIL Allen; AEMO

Growing the rooftop PV generation traces for each year

ACIL Allen has constructed a representative hourly PV output trace for PV systems installed in each region (see Figure G.3). The traces are derived from data on real system output obtained from pvOutput.org. The PV traces are from systems distributed over a wide geographic area which accounts for the diversity of systems installed in each region.

These traces are then scaled to the assumed annual generation parameters. The scaled traces are then deducted from the projected hourly underlying demands.

Figure G.3 Annual average time of day rooftop PV generation profile



Source: ACIL Allen

G.5 Projection of behind-the-meter BESS uptake

Household battery storage systems are currently economically unviable, due to high installation costs, technical limitations relating to depth of discharge and the number of charge/discharge cycles that can be achieved. The number of cycles that can be achieved with a system plays a crucial role in determining its profitability. At a given rate of use, the number of cycles amounts to the system's useful life.

Benefits to end user customers from using an energy storage system include:

— storing solar generation that would otherwise be exported to the grid, thus enhancing the financial value of that electricity to the customer
— avoiding network charges especially charges related to peak network demand charges (noting that most households are not charged for peak demand at present, though this is likely to change in the medium term)
— using lower priced electricity to meet daytime energy demand.

By storing excess solar generation in a BESS, customers forego any payments they would otherwise receive for electricity exported to the network (renewable energy buyback rates or feed-in tariffs). The net benefit to households from storing excess solar generation arises from the difference in the renewable energy export rate and the variable electricity tariff.

In addition to storing excess solar generation, customers who install a BESS and face different tariffs for energy consumption depending on the time of consumption can buy electricity during low price periods and use it when electricity from the grid would be more expensive.

ACIL Allen's assumptions

ACIL Allen's BESS uptake model relates installation rates of home BESS to the NPV a household achieves by installing such a system. We have assumed that the relationship between NPV and installations rates of home BESS will be similar to the relationship between NPV and installation rates of PV systems which is observable. All existing and future solar installations are assumed to be candidates for the installation of BESS.

The economics of battery installations are also affected by the technical characteristics of battery technology. The nature of battery cycling affects battery life – non-optimal cycling can lead to shorter battery life. We assume daily cycling of the battery with a depth of discharge of 80 per cent and a lifetime of 10 years (equivalent to 3,650 cycles in its lifetime). For our projections we have assumed that battery costs decline by six per cent per annum in real terms.

The projected cumulative installed behind-the-meter BESS capacity is illustrated in Figure G.4.

Figure G.4 Projected cumulative installed behind-the-meter BESS capacity by region (MWh)

Source: ACIL Allen

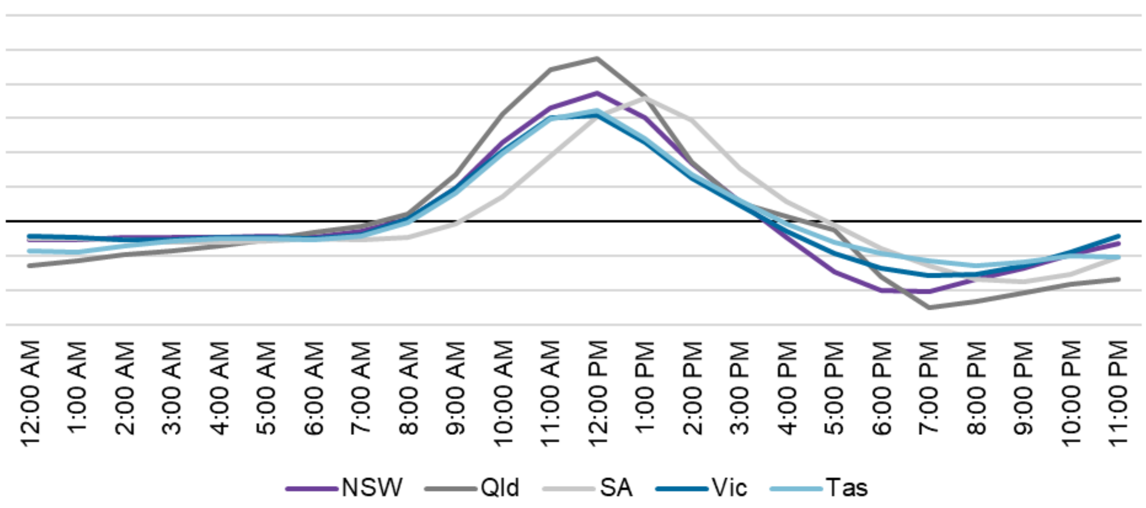
Growing the BESS operation traces for each year

The impact of home energy storage systems will depend on the way these systems are charged and discharged as well as the overall system size.

In the reference case we have assumed that charging and discharging will occur on the basis of a daily cycle where excess solar generation is stored until the storage capacity is reached. Once household electricity demand exceeds solar generation the storage system is fully discharged – typically during the evening peak (see Figure G.5).

Similar to the treatment of rooftop PV, the BESS operation trace is grown and deducted from the projected underlying hourly demands.

Figure G.5 Annual average time of day BESS operation profile



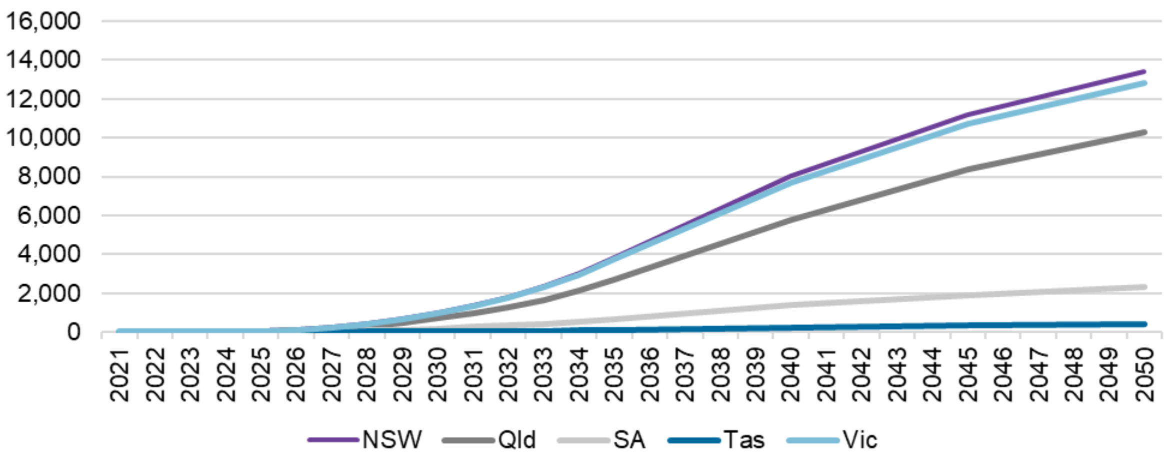
Source: ACIL Allen

G.6 Projection of EV uptake

ACIL Allen has adopted AEMO's projection on the uptake of EVs as published in its latest ESOO. The projected uptake of EV in the NEM suggests little uptake prior to 2030. This is not surprising given the price differential between EV and conventional vehicles at present, as well as the limited choice of model.

However, by 2030, the economics of EV are projected to have improved. This, coupled with various producers announcing moving to EV production only from 2030 onwards leads to a substantial uptake in electric vehicles. The annual contribution of electric vehicles to each region's energy consumption is shown in Figure G.6 and amounts to about 39,000 GWh by 2050 NEM-wide.

Figure G.6 Projected annual energy requirements of EV charging (GWh)



Source: ACIL Allen analysis of AEMO data

G.7 Aluminium smelters

The continued operation (or closure) of Australia's aluminium smelters is an important assumption in the demand forecast of the NEM as they are significant consumers of electricity, representing over 10 per cent of the total NEM operational consumption. The latest ESOO central scenario assumes the smelters remain in operation. The reference case makes the same assumption.

Based on analysis ACIL Allen has undertaken in previous engagements with various stakeholders in the aluminium smelting industry, our understanding is that existing smelters in Australia sit in the lower to mid-quintiles of the global supply cost curve at present. This is largely due to competitive power supply contracts, including subsidies for generation and transmission costs.

Our understanding is that should annual time-weighted wholesale electricity prices rise above $50 / MWh on a sustained basis (so as to impact the renewal of their electricity supply contracts), the smelters would be unable to maintain their competitive position in the global supply curve and would therefore be likely to close down their operations.

Given that the projected wholesale prices in the reference case tend to sit below this level out to 2030, as a result of the large volume of additional generation supply (almost exclusively driven by state government policies), the smelters are assumed to continue their operations throughout the projection period. Post 2030, prices are projected to rise above $50 / MWh, however, as has been observed in the past, government subsidies also play an important role in determining whether a smelter continues to operate. It is difficult to determine what the political appetite may be by 2030 to support Australia's aluminium smelting industry. ACIL Allen has therefore aligned with AEMO's demand forecast and kept the smelters operational post 2030.

Stakeholder consultations H

As part of the development of this RIS, ACIL Allen undertook informal consultations during with a limited number of stakeholders to gather stakeholder views about the impacts of proposed amendments to the NCC.

The stakeholders consulted through these workshops are outlined in the table below. Their views and input have been reflected where appropriate throughout the RIS.

Table H.1 Stakeholders consulted during preparation of this RIS

Organisation	Date
Australian Glass & Window Association Building Products Industry Council Lighting Council Illuminating Engineering Society of Australia & New Zealand Insulation Council of Australia & New Zealand Gas Appliance Manufacturers Association of Australia Australian Water Heating Forum Australian Industry Group	Thursday 20 May 2021
Master Builders Association Australian Institute of Architects National Association of Steel Framed Housing Australian Institute of Building Surveyors Master Builders Queensland Master Builders Victoria Property Council	Thursday 20 May 2021
Housing Industry Association	Monday 24 May 2021
Australian Energy Regulator	Tuesday 25 May 2021
Energy Networks Association	Friday 28 May 2021
Australian Energy Market Operator	Tuesday 1 June 2021
Australian Energy Market Commission	Friday 4 June 2021

Source: ACIL Allen Consulting.

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