ABCB

Inclusion of heating and cooling energy load limits in NatHERS assessments

Regulation Impact Statement for decision

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Inclusion of Heating and Cooling Energy Load Limits in NatHERS assessments

Final Regulation Impact Statement for Decision

Prepared for the Australian Building Codes Board, October 2018

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Executive Summary

Purpose

This Decision Regulation Impact Statement (RIS) examines the expected impacts, including costs and benefits, associated with a proposal to add separate heating and cooling load limits or 'load limits' to the current Nationwide House Energy Rating Scheme (NatHERS) compliance pathway for the energy performance of residential buildings in the National Construction Code (NCC, or the Code). The separate heating and cooling load limits would be in addition to the current NatHERS rating requirements in the Code, but would be set at a level that is not intended to change stringency.

The purpose of this Decision RIS is to:

- Establish and quantify the extent of the problem
- Quantify the extent that the problem is managed by options including but not limited to imposing separate heating and cooling load limits
- Quantify costs and benefits of options including the status quo and regulatory and voluntary responses
- Summarise and respond to stakeholder comments and submissions received in response to the Consultation RIS
- Make clear recommendations for decision.

The Problem

At present, it is estimated that at least 70% of new dwelling designs demonstrate compliance with the NCC energy efficiency requirements via the NatHERS compliance pathway.[1] In most states and territories, the current requirement is a minimum of 6 stars, which refers to a specific annual average thermal load limit (in MJ per sqm per year) in each climate zone. NSW has for many years applied separate heating and cooling load limits via its BASIX scheme, which is a NSW variation.

Because the Code requirement for a NatHERS rating represents an annual average thermal load allowance, it allows dwellings to comply with the Code requirements while potentially over-performing in one season (typically, the dominant one, such as winter in a cool climate zone, and summer in a hot one) and, as a result, under-performing in the opposite season. Such designs will require excessive heating or cooling in the non-dominant season in order to maintain safe and comfortable living conditions without excessive energy consumption and cost. Some suggest that the current arrangements are contributing to a situation where some dwellings perform very well in winter but poorly in summer, resulting in designs that are disparagingly called 'hot boxes'. At the

[1] Personal communication with the NatHERS Administrator.

same time, designs over-optimised for summer performance can perform poorly in winter. Feedback from the building industry suggests that concerns about these issues are reducing confidence in NatHERS as a compliance pathway.[2]

Importantly, since the designs in question are generally over-specified for the dominant season, they are likely to be more costly to build than necessary. Correcting this over-specification can therefore lead to reductions in overall construction cost, while also reducing energy consumption and associated externalities over a given year. For example, many designs modelled by Tony Isaacs Consulting (TIC)[3] in warmer climates were able to reduce insulation levels (under slabs, in walls or roofs), leading to more balanced year-round performance and also lower construction costs.

Analysis by TIC indicates that around 10% of designs are, in effect, over-optimised for one season but liable to perform poorly in the opposite season.[4] If such dwellings did not have appropriate (and working) building services, occupants could experience poor comfort standards during weather extremes, risking poor health outcomes and a (small) increase in the probability of fatalities.[5] Assuming adequate building services, significant energy consumption may be required to correct for the unbalanced thermal performance. In addition to raising energy costs, this extra consumption may also contribute to demand at times of peak load, requiring additional investment in electricity networks to cover the anticipated load. Finally, the additional energy consumption would generate additional greenhouse gas emissions.

The existence and extent of this problem is documented in the above-mentioned reports. TIC captured data on over 170,000 NatHERS ratings, from actual dwellings around Australia, and determined heating and cooling load limits for each climate zone using a statistical analysis of this data, without changing the overall (mainly 6 star) stringency. Specifically, they identified the 5% of designs with the highest heating loads, and the 5% of designs with the highest cooling loads, in each climate zone. This – together with the degree to which those designs exceed the proposed new load limits – defines the extent of the problem.

Against this background, the objective is framed as ensuring that the new dwelling stock comprises designs that perform well in *both* summer and winter, while inducing (minor) changes in the design and/or specification of the small percentage of designs that would represent extreme outliers in terms of either excessively high heating load intensity or excessively high cooling load intensity.

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[2] For industry views on these issues, see pitt&sherry/Swinburne University of Technology, *National Energy Efficient Buildings Project: Phase 1 Report*, December 2014.
[3] Tony Isaacs Consulting and Energy Efficient Strategies, *Principles and Methodology for Setting NCC Heating and Cooling Load Intensity Limits,* undated; and *The Impact of Heating and Cooling Load Intensity Limits on NCC Compliance,* undated.
[4] This value derives from statistical analysis designed to require changes to the 5% of designs with the highest heating loads, and the 5% of designs with the highest cooling loads, in each climate zone.
[5] As discussed in Chapter 2, there is a paucity of research with which to correlate fine degrees of change building thermal performance with morbidity and mortality outcomes in Australia. That said, it is very well established that there are additional deaths associated with poor thermal performance, in both cold and hot weather. Therefore, it is reasonable to assume at least a qualitative health benefit associated with improved thermal performance, particularly when focusing on improving 'outlier' designs, as we do here. We do not attempt to quantify such benefits, however.

Options

This RIS examines three options:

1. A continuation of the status quo; that is, star ratings but no separate heating and cooling load limits
2. Regulatory implementation via Code changes and an ABCB Standard for NatHERS Heating and Cooling Load Limits, supported by an awareness-raising and education campaign
3. Voluntary implementation, supported by an awareness-raising and education campaign.

Exclusions

TIC proposed that this measure should not apply in the Northern Territory, and in certain (northern) climate zones in Western Australia and Queensland, as these climate zones normally experience only cooling loads; while Tasmania should be excluded as it normally only experiences heating loads. In addition, NSW has been excluded from this analysis, as its BASIX scheme (which applies as a state variation) already applies separate heating and cooling load limits.

Solutions

TIC identify that the substantive solution to the identified problem is to encourage designers and builders to make generally minor changes to the design or specification of the small percentage of 'outlier' designs, to improve their performance in the season where they would otherwise perform poorly. We note that this can be achieved without trading off performance in the opposite season, as these outlier designs are, by definition, over-performing in this season already (assuming they comply with 6 stars in general). The strategies vary by climate zone and design, and also by floor type for Class 1 dwellings, and will be unique to specific designs, but they include:

- Varying insulation levels (including reducing them for some surfaces)
- Varying the albedo or colour of roofing materials, exterior finishes, window frames, or glazing tint
- Changing eave widths (including reducing them in some circumstances)
- Adding ceiling fans or external blinds
- In some cases, variations in window sizes or specifications for specific windows (not whole dwellings).

Some of these strategies are cost-saving; some are cost-neutral; and some would incur a net cost, albeit generally small. We note that identifying the least-cost strategies in a given case will require that the energy assessor applies a sound understanding of building physics, as should be the case if they are appropriately trained and aware of the relevant issues (see comments on education and training below). There should be no incremental cost in the energy assessment process, as assessment costs will be incurred with or without this potential change.

Benefit Cost Analysis

The benefit cost analysis finds that Option 2 – the regulatory approach – is the most effective option, with an expected net present value (NPV) of $71.7 million, comprising energy and related externality savings of $20.7 million, together with construction cost savings (net of other costs) of some $51.1 million. These estimates assume that the industry consistently selects least cost solutions, which in turn assumes that they are well informed regarding the issues and options. This is why an awareness raising and education program is proposed to be undertaken as part of this option.

These values may be compared to an NPV of $19.1 million for Option 3, comprising energy and related savings of $3.9 million and construction cost savings (net of other costs) of $15.2 million (see Table 1). Overall, Option 2 offers almost four times the net economic welfare of Option 3. Benefit cost ratios (BCR) for both options 2 and 3 are negative, because construction costs are expected to fall on average in both cases. This more than offsets information/education and related costs, while benefits are positive in both cases. The NPVs provide better indicators of the net benefits of the two options than do the BCRs.

Table 1: Comparison of Key Indicators – Regulatory vs Non-Regulatory Option – All Dwellings

a. Present value of benefits ($'000)

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	$10,174	$1,942
QLD	$2,885	$562
SA	$1,801	$342
WA	$5,150	$981
ACT	$583	$111
Total	**$20,594**	**$3,938**

b. Present value of costs ($'000)

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	-$24,573	-$7,206
QLD	-$6,044	-$2,515
SA	-$1,083	-$533
WA	-$17,938	-$4,653
ACT	-$1,451	-$259
Total	**-$51,090**	**-$15,166**

c. Net present values ($'000)

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	$34,748	$9,149
QLD	$8,928	$3,077
SA	$2,884	$875
WA	$23,089	$5,633
ACT	$2,035	$370
Total	**$71,684**	**$19,105**

Notes: Present values of benefits have been calculated using a 7% real discount rate over the 40 year assumed life of dwellings; while the present values of costs have been calculated using a 7% real discount rate over the assumed 10 year life of the proposed measure. All references to dollars are FY2019 real.

The primary reason for the superior results of the regulatory option is that it is expected to lead to a much higher rate of implementation of what is shown to be a cost-effective measure. The regulatory pathway ensures high (if not 100%) compliance – within the estimated 70% of completions that choose the NatHERS compliance pathway – while the available evidence suggests that take-up and implementation on a purely voluntary basis, even when supported by a well-designed and implemented information and education program, would be likely to be low.[6] This view was reinforced by the majority of stakeholder submissions received in response to the Consultation RIS. For dwellings that demonstrate Code compliance using the 'deemed-to-satisfy' (DTS) elemental provisions, no heating or cooling load limits will apply. The Australian Building Codes Board (ABCB) understands, based on internal modelling work, that dwellings (including additions and alterations) complying with DTS elemental provisions are not expected to exhibit unbalanced heating and cooling loads, making separate load limits redundant. As discussed in Chapter 2, unbalanced loads can, however, arise under NatHERS due to the annual average nature of the thermal load performance requirement, which allows for a very wide range of compliant solutions, including some that may have poorly balanced heating and cooling load performance.

On the question of compliance, the existing Universal Certificates issued under the NatHERS scheme already clearly identify the modelled heating and cooling loads of designs. This would facilitate compliance-checking and enforcement activities, as well as enabling data capture (by agreement with CSIRO, the data owner) for regulatory review and evaluation purposes in future. This proposal is therefore not expected to impact on Code compliance rates, either positively or negatively. Also, we are not aware of any evidence that rates of compliance with Code requirements, including energy performance requirements, vary by dwelling class or market segment. As a default, we assume that dwellings will comply with the limits if imposed via the Code. That said, we note that any non-compliance with the load limits would essentially continue the status quo, with neither

[6] pitt&sherry/Swinburne University of Technology, *National Energy Efficient Buildings Project – Phase 1 Report*, December 2015, Chapter 7 (Knowledge Management).

costs nor benefits arising, but with continued opportunity costs, as is also the case under Option 1, status quo.

Sensitivity Analysis

Chapter 4 includes extensive analysis of the extent to which changed assumptions in the above analysis would have a material impact on the analysis. We find that the measure is insensitive to a wide range of contingencies. Higher discount rates reduce modelled NPVs, but benefit cost ratios remain negative. As noted above, the only variable that the measure is sensitive to is the cost of the solutions implemented. Even then, the measure remains cost effective (Option2) provided that not more than 25% - 36% (depending on the building class) of solutions implemented are the *highest*-cost solutions. This is not expected – indeed, as discussed below, the majority of stakeholders expect least cost solutions to be the norm – but rather these values are calculated in our benefit cost analysis model as the limit of the measure's ability to tolerate deviation from least cost solutions. While least cost solutions are expected to be selected in most cases, as reflected in stakeholder comment (see below), two possible exceptions are noted.

The first is 'high end', architect-designed dwellings where least cost solutions could conflict with the owners' preferences, for example regarding the colour of roofs, windows or external walls. The size of this market segment is not known precisely but is likely to be relatively small. By contrast, in the high-volume project home market, builders are more 'sovereign' over many design and specification choices and, as stakeholders noted, these builders are very likely to choose least-cost solutions, as this is a highly competitive segment of the market. For Class 2 apartment buildings, very few buyers would expect to be able change floor plans or other construction or finishing details, which means that builders/designers will be able to choose and implement least cost solutions.

A second possible deviation from least-cost solutions would be inadvertent, if the relevant industry professionals (designers, primarily, but also energy assessors) were not well informed about the issues and options, and – for example – incorrectly applied 'rule of thumb' solutions rather than discovering and applying least-cost solutions for the particular dwelling. The risk of high-cost solutions being chosen inadvertently would be reduced by an effective information and education program for industry professionals, and is also likely to diminish over time, as knowledge about this issue spreads and default practices change.

Thus, it is likely that some people will choose higher cost solutions under the regulatory option (e.g. on aesthetic grounds or for other reasons). This may lead them to adjust other parts of the design or structure to meet the heating or cooling load limits relevant to the Class of building and climate zone. While the number of people choosing the higher cost solution is expected to be minimal, there is still a risk that they will face higher costs under the preferred option.

Stakeholder Consultation

The majority of stakeholders that made submissions in response to the Consultation RIS:

- Agreed that the measure addresses a substantive issue
- Supported a regulatory rather than voluntary implementation pathway
- Supported an awareness-raising and education program being an integral part of the measure
- Agreed that least-cost choices are viable and likely to be selected in the majority of cases.

Stakeholders noted that the issues involved in heating and cooling load limits are not necessarily well understood within industry, let alone by stakeholders. It was further noted that there could be instances where least cost solutions (for example, changing the colour of surfaces) could conflict with aesthetic preferences. This in itself could be considered an intangible cost on home owners. Stakeholders noted that these factors could contribute to a limited implementation of this measure on a voluntary basis.

Implementation

As discussed in Section 3, further work has been undertaken to specify the implementation details for the regulatory option. It is proposed that the Code would be amended such that clause J0.2(a) for Class 2 sole-occupancy units (SOUs) and Class 4 parts of buildings would require to collectively achieve an average energy rating of not less than 6 stars, *including the separate heating and cooling load limits*, and individually achieve an energy rating of not less than 5 stars, *including the separate heating and cooling load limits.* The limits would be published on the ABCB's website as the *ABCB Standard for NatHERS Heating and Cooling Load Limits*. Similarly, for Class 1 dwellings, clause 3.12.0.1(a) would specify that a building must achieve an energy rating, including the separate heating and cooling load limits, and include a new clause 3.12.0.1(b) specifying that the heating and cooling load limits in (a) are specified in the ABCB Standard for NatHERS Heating and Cooling Load Limits. The ABCB Standard for NatHERS Heating and Cooling Load Limits will be available on the ABCB's website. The NatHERS Administrator has indicated that if Option 2 were to proceed, they would seek to implement two changes:

1. A separate section will be included at the bottom of Universal Certificates with text to refer to the NCC for energy efficiency requirements, including the separate heating and cooling load limits
2. Software tool developers will include a text prompt in their software alerting assessors to check the calculated heating and cooling loads against the NCC heating and cooling load limits prior to the Universal Certificate being generated.

Regulatory Burden

The cost burden for industry associated with the regulatory option averages *minus* $7.8 million per year over the 10 year period (see Table 2). This figure represents the net effect of construction cost reductions, on average, offset by redesign, training time and Standard-checking time costs. We show the negative construction cost as accruing to industry in the first instance, but in competitive markets, a significant share of this cost saving would be expected to be returned to house owners.

Table 2: Regulatory Burden ('000)

Change in costs	Business	Community organisations	Individuals	Total change in costs
Total, by sector	-$7,815	0	0	-$7,815

Conclusions

We conclude, firstly, that implementing the measure would be cost effective and generate a material net benefit for society, with positive net impacts for the building industry, including reduced construction costs.

Second, implementing the measure via regulation would be considerably more effective than implementing it on a voluntary basis, primarily due to the expectation of much higher uptake of the measure via a regulatory pathway. Some uptake would be expected on a voluntary basis, due to the evidence that some load limit solutions reduce overall construction costs. The key limitations would be the lack of awareness of both the issue and the cost reduction options, together with the lack of a regulatory driver for the designer to suggest design/specification changes to the developer or prospective home owner. Overall, the regulatory option generates significantly greater net economic welfare than the non-regulatory option, acknowledging that preferences will be restricted to more energy efficient choices under the regulatory option.

Third, whether the measure is implemented voluntarily or by regulation, an effective information and education program is warranted and expected to be highly cost effective.

Finally, we note that implementation of the measure on a regulatory basis is supported by a significant majority of stakeholders, while the same stakeholders express concern about the limited uptake and impact of a voluntary solution.

Key assumptions:

1. Separate heating and cooling load limits are implemented in relevant climate zones, in addition to the current star rating requirements, for those who choose to use the NatHERS compliance pathway, as specified in the *ABCB Standard for NatHERS Heating and Cooling Load Limits.*
2. Clause J0.2(a) for Class 2 SOUs and Class 4 parts of buildings be amended to require collectively achieving an average energy rating of not less than 6 stars, *including the separate heating and cooling load limits*, and individually achieving an energy rating of not less than 5 stars, *including the separate heating and cooling load limits.*

3. Clause 3.12.0.1(a) for Class 1 dwellings be amended to specify that a building must achieve an energy rating, *including the separate heating and cooling load limits*…of greater than or equal to 6 stars in general…
    a. and include a new clause 3.12.0.1(b) specifying that the heating and cooling load limits in (a) are specified in the *ABCB Standard for NatHERS Heating and Cooling Load Limits*.
4. The heating and cooling load limits are published on the ABCB's website as the *ABCB Standard for NatHERS Heating and Cooling Load Limits*.
5. The NatHERS Administrator includes text within NatHERS Universal Certificates that refers to separate heating and cooling load limit requirements and encourages checking of modelled results against the *ABCB Standard*.
6. Ratings tool developers include at least a text prompt in their software, to alert assessors to check the calculated heating and cooling loads against the NCC heating and cooling load limits, prior to the Universal Certificate being generated.
7. The ABCB works closely with states and territories and industry associations and professional bodies to design and implement a suitable awareness raising and education campaign to support the implementation of the separate heating and cooling load limits.

1. Introduction

The ABCB is committed to maintaining a contemporary NCC that helps ensure that the community use buildings with amenity appropriate to their purpose and that are safe, healthy and sustainable.

Keeping the NCC up to date involves an ongoing process of consultation, research and evaluation.

When a potential need for regulatory adjustment or change to the NCC is identified, the ABCB follows a nationally recognised framework to assess regulatory proposals. This framework follows the Council of Australian Governments (COAG) *Principles of Best Practice Regulation – A Guide for Ministerial Councils and National Standard Setting Bodies*. The ABCB has published a *Regulation Impact Analysis Protocol* that succinctly summarises the process of analysing regulatory impacts.

This Decision RIS examines the potential adjustment of requirements for Class 1 dwellings, Class2 SOUs and Class 4 parts of a building under clauses 3.12.0.1 and J0.2 in NCC Volumes Two and One respectively.

The proposed change is to amend the existing NatHERS assessment to include clearly defined heating and cooling limits, as a requirement for Class 1 dwellings, Class 2 SOUs and Class 4 parts of a building under clauses 3.12.0.1 and J0.2 in the NCC, in addition to the existing star requirement (mainly 6 star), in relevant climate zones. No change to the stringency of the NCC energy efficiency provisions for dwellings is intended.

The NCC provides a compliance pathway where designs of Class 1 dwellings, Class 2 SOUs and Class 4 parts of a building must achieve 6 stars or better under NatHERS, although some local variations are in place. In NSW, the BASIX system is a state variation to the NCC energy efficiency provisions. Class 1 buildings in ABCB climate zones 1 and 2 are permitted to be a lower energy rating of 5.5 stars if the home has an outdoor space. 5 stars is permitted in those climate zones if the outdoor space also has a ceiling fan. The star ratings refer to maximum annual thermal load limits, based on an average climate year, and according to a detailed software protocol maintained by the NatHERS National Administrator. Other compliance pathways exist, but these are not affected by this proposed change.

The energy rating metric in NatHERS is MJ/m^2.year of combined heating and cooling load intensity for a typical year of hourly weather data. The 6 star rating currently sets a maximum *combined* heating and cooling load intensity for each climate zone. These maximum combined load limits are proposed to remain at current levels. However, the ABCB is investigating the merits of having the combined heating and cooling limits with <u>separate</u> limits for heating and cooling loads. That is, designs using the NatHERS compliance pathway would need to achieve the current minimum star rating (as per current arrangements) and also meet the new, separate heating and cooling limits.

It is reasonable to expect that impacts of the proposed adjustment will be minor, given that the overall stringency will be unchanged. This is because designs with poor performance in one season by definition are over-complying with load limits in the opposite season. Therefore, at the same time as changes are made in one season, offsetting changes can be made to designs to reduce the extent of over-compliance in the opposite season, while the sum of the heating and cooling loads will remain the same as before.

Examination of energy rating files shows that 90% of residential buildings will be unaffected, even in states/climate zones where the measure is applied. It is expected that around 5% of designs in affected states/climate zones would need to make small improvements to their cooling load performance. Another 5% of homes in affected states/climate zones would have to slightly improve heating load performance.

This Decision RIS explores the potential impact of the proposed change by:

- Identifying the problem and explaining why action is necessary for a resolution
- Setting out options for addressing the problem
- Analysing the impacts of options – including their benefits and costs along with other impacts on market dynamics (such as competition)
- Summarising the key points raised in consultation, and analysing how these may alter the understanding of the problem and/or the options
- Drawing conclusions and recommendations for proposed changes to the NCC in 2019.

2. The Problem

2.1 Overview

NatHERS uses a thermal load intensity limit – that is, the sum of annual heating and cooling loads (under standardised conditions, including average weather) – to determine the energy star ratings used for an NCC energy efficiency compliance pathway for Class 1 dwellings, Class 2 SOUs and Class 4 parts of a building. This can lead to designs that are chiefly focused on performance under the thermal load that dominates energy use in that climate (e.g., summer in a warm climate, and winter in a cool one). It is possible for designs that minimise heating loads but without also managing cooling loads, to meet the NatHERS combined load limit, and vice versa. Such designs, which are outliers on the energy performance spectrum, have unbalanced thermal performance under the full range of weather conditions experienced in most Australian climate zones. This means that these dwellings will offer relatively poor standards of comfort and amenity in more extreme weather events, if unheated or uncooled, or alternatively require excessive artificial heating and cooling (relative to 90% of designs) to maintain comfort.

However, industry feedback to policy makers on the energy efficiency provisions of the NCC has included a concern that the current annual average thermal load requirement can lead to designs that are over-optimised for one season, and under-optimised for the opposite season. This can lead to poor thermal comfort (in the opposite season), and hence excessive space conditioning energy consumption.

The *National Energy Efficient Building Project* found, for instance, considerable stakeholder concern with what is known as "hot box syndrome".[7] This refers to homes that perform well in winter conditions (minimising energy demand for heating) but poorly in summer (with concerns about over-heating). Such homes may require large quantities of cooling energy to bring comfort to acceptable levels.

While we are not aware of quantitative research specifically designed to test the evidence for such a syndrome, there is evidence that supports the view that some homes do not have well-balanced performance under both heating and cooling loads. For example, CSIRO evaluated the previous NCC 5 star standard for residential buildings, including via long-term monitoring of the internal temperatures of homes, energy bills and many other parameters. While the study acknowledged that many variables (a hotter than normal summer, varying occupant behaviour, potential sampling errors, etc.) were factors, one finding was that some of the 5 star homes – notably in the warmer Brisbane climate – used more energy in summer than did the lower rated homes (3 or 4 stars).[8]

An RMIT study of homes in regional Victoria has also found that a cohort of 6 star rated homes performed badly in summer heat. Occupant behaviour and weather conditions were a significant

[7] Pitt & Sherry, Swinburne University, 2014, *National Energy Efficient Building Project*, Department of State Development – Government of South Australia

[8] CSIRO, 2013, *The evaluation of the 5-Star energy efficiency standard for Residential Buildings, Report to the Department of Industry*, Commonwealth of Australia

influence, nevertheless the results are a strong indicator of poor cooling load performance. The standardised internal temperature of living rooms at a 30 degree outside temperature was 28.8 degrees. At 40 degrees outside, the internal temperature was 33.8 degrees. These temperatures occurred across a set of homes with electric air-conditioning systems. The study also found that, using the European adaptive comfort standard criteria, that living rooms were uncomfortable for 40.3% of an average summer day.[9]

Higher energy use causes household energy costs to rise and increased greenhouse gas emissions (the quantity of emissions vary by the energy source used for heating and cooling). Depending on the timing of the additional energy use, there can also be increased peak electrical loads which can strain system reliability (higher risk of brown and black outs) and put upward pressure on system costs (increased demand for transmission capacity).

In certain cases, occupant comfort can remain poor, despite the use of additional energy, or if building services fail. This can cause cold stress during winter conditions, leading to discomfort and increased rates, across the population, of respiratory illness and cardiovascular problems that can lead to fatalities. In summer heatwaves, heat stress can occur causing discomfort, increasing the risk of dehydration which can potentially lead to hospitalisation and fatality.

We have not attempted to quantify the potential health benefits of the proposed regulatory changes. This is because of the difficulty in establishing rates of health impacts of cold and heat stress that can be attributed to unbalanced thermal performance in new dwellings. However, the challenges in quantifying health impacts does not mean that they should be ignored. There is abundant evidence that cold and heat stress can lead to serious health problems.[10]

“Hot boxes” appear to dominate industry concerns, but the reverse can also apply. In climate zones in northern Australia, houses are often well-suited to summer with extensive shading and excellent ventilation. However, such homes may have high heating loads on cool days. Overall, designs that perform well in managing both heating and cooling loads deliver better overall occupant comfort, energy efficiency and lower greenhouse gas emissions. Well-balanced house designs also better manage weather variations and extremes, helping to contain peak loads on electricity networks in particular. These factors are the rationale for NCC requirements for energy efficient designs that suit specific climate conditions.

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[9] Dr T Moore, Dr Y Strengers, Dr C Maller, Dr I Ridley, Dr L Nicholls, Prof R Home, 2015, Final Report: Horsham Catalyst Research and Evaluation, commissioned by the Department of Health and Human Services, Victorian State Government. Centre

[10] Gasparrini, Antonio et al “Mortality risk attributable to high and low ambient temperature: a multicountry observational study”. *The Lancet*, Volume 383, Issue 9991, 369-375

The Consultation RIS asked stakeholders about whether heating and cooling is considered already, while others reflected on the nature and/or significance of the problem addressed in 'other comments'.

On the question of whether heating and cooling is already separately considered, most submissions indicated that practices vary widely. 15 provided qualified support – there were no clear statements of 'yes'. Many of those answering 'yes' gave examples of poor practices they were aware, or noted that attention to this issue is limited to certain locations, or referred to evidence of poor cooling performance in particular, and/or that it is cheaper for builders to improve winter performance than summer performance. 13 provided no response. 3 indicated 'no', noting NatHERS tools not making it easy to find information on load limits; load limits being poorly understood by industry and/or consumers; or 'being at the bottom of the list in terms of importance'.

The majority of submissions recognised the importance of the problem and agreed that action should be taken to address it. Numerous submissions referred to 'fixing the worst 10%' of the housing designs, and noted that 90% would be unaffected. Several submissions provided examples of compliant designs with very high cooling loads, or designs being rated as 6 star while possessing features that they assessed were inappropriate for the climate and that would lead to high energy consumption to maintain comfort. One submission asked that hot box syndrome – and particularly high temperatures in roof spaces – be recognised as a serious threat to human health, including tradespeople that may need to work in such spaces.

Several submissions referred to climate change and rising urban temperatures as part of the problem, while others noted the role of occupant behaviours and understanding – such as use of blinds and cross-flow ventilation. Similarly, numerous submissions referred to a lack of understanding of passive design principles or building physics as a key underlying issue contributing to designs that were inappropriate for their location. Generally this was linked to a call for more education and awareness raising.

The Housing Industry Association noted that '…the changes seem to be addressing a 'perceived' issue rather than addressing an actual issue, and recalled at the goal of the NCC is to be '…applied so that there is a rigorously tested rationale for the regulation'. We note that a detailed investigation of the issue was prepared by Tony Isaacs and Robert Foster ahead of the Consultation RIS (TIC 2018).

Several submissions suggested that at least part of the problem is the nature of the climate files and/or zones in NatHERS, with comments including that climate files were insufficiently targeted to local climate conditions, or that climate boundaries were arbitrary. It should be noted, however, that assessors may use secondary or even tertiary climate zones when they believe the 'principal' climate zone is not appropriate for a particular location. Detailed issues relating to the administration of NatHERS fall outside the scope of this RIS. However, there are a number of specific issues that are directly relevant to heating and cooling loads that are covered below.

Many submissions suggested that poor compliance with existing energy efficiency requirements may be part of the problem, referring for example to a lack of inspections at critical times. The Victorian Building Authority has commenced a major program of audits to determine the extent of any under-compliance with energy performance requirements in housing in that State, but no results are available at this time. That said, the problem identified here and detailed in TIC (2018) is primarily related to the design and specification of new dwellings in relation to their location and climate, and how that impacts on heating and cooling loads, and this is essentially a separate question from that of compliance.

Overall, the majority of stakeholders appear to accept this is a genuine problem.

2.1.1 Information Barriers and Regulatory Credibility

The design of a house or apartment with good thermal performance in both summer and winter is readily achievable, including in the wide range of climates across Australia. However, many factors and variables are at play and the design process is consequently complex.

Thermal performance is affected by every aspect of a house/apartment. First there is the site to consider – the relevant climate zone (there are 69 climate zones that are separately considered under NatHERS), site conditions, aspect/solar orientation, etc). Second there is a myriad of building design factors: overall size; room size; cladding, window frame and roof material choice and colour; insulation levels; window to wall ratios; ceiling heights; eave width; shading features; window dressings, etc. The list of design features with an impact on thermal performance is very long.

The NatHERS software referenced under clauses 3.12.0.1 and J0.2 of the NCC considers all these factors when generating energy ratings of homes. The rating metric is MJ/m^2.year, with the figure determined by annual total thermal energy load (i.e. the sum of heating and cooling loads).

NatHERS uses a highly sophisticated, physical science-based engine developed by CSIRO (called Chenath). NatHERS accredited software (AccuRate, BERS and FirstRate5) are the front end of the Chenath engine and play a vital role in meeting the technical challenge of estimating the thermal performance outcomes of designs and design changes.

In the residential construction market, the roles of design and thermal performance assessment are performed, in the main, by designers, architects and energy assessors.

In terms of information flows within the market, these professionals using NatHERS software are the chief holders of design and thermal performance expertise and knowledge. They play the role of informing other market participants of the ramifications of design inputs on thermal performance. Most builders for instance will understand thermal performance concepts and appreciate the complexity of the design and thermal performance interface. However, most builders are reliant on the design professionals for the provision of precise information on thermal load management – in the same way that they might rely on engineers to design or approve structural design features.

Home buyers are generally not expert in aspects of home design and the construction process, and will generally not be well-equipped to exercise informed judgement or choice on technical aspects of design – including heating and cooling loads – with expert support, who in turn use tools such as NatHERS. The star-rating metric of NatHERS has the merit of simplicity – a higher star rating can be interpreting as indicating that a given design will require less energy, in an average year, to maintain thermal comfort than a lower-rated design. Also, as a 'performance-based' solution, choosing the NatHERS verification path means that designers are not required to use certain elements, but rather have the freedom to vary elements, specifications and designs, provided the finished result complies with the required star rating.

However, with the benefit of hindsight, the quest to simplify the complexities of building physics into a single metric, the differing performance of designs by season may have been obscured, reducing the quality and quantity of information available to help consumers make good decisions. Markets are most effective and efficient when information quality and regulatory credibility is high. Separate load limits would provide new information that will help the residential construction market make better-informed decisions. Better energy performance with lower compliance costs is possible, where actors value these outcomes sufficiently influence their preferred designs.

The ABCB has examined options for improving the heating/cooling load performance of dwelling designs without changing the overall stringency of energy performance requirements in NCC2019, which will remain mainly at 6 star (including a 6 star average for Class 2 dwellings). A design that requires modification to achieve a cooling load limit, for example, will by definition be over-performing relative to a heating load limit, as the current annual average requirement is the sum of the heating load limit and the cooling load limit: if one is tightened, the other must be relaxed. Practically this means that such as design may be modified both to improve its cooling load performance, but also to relax its heating load performance, with the overall change in construction cost reflecting both changes. The same occurs for designs that requires modification to meet a heating load limit: for a given level of stringency, that design will be over-performing relative to a cooling load limit, enabling design or specification changes to be made that may reduce construction cost.

2.2 The Extent of the Problem

Extensive research by TIC has developed heating and cooling limits for each climate zone and dwelling class that aim to preclude the 5% of designs with the highest heating load, and the 5% of designs with the highest cooling load, based on over 170,000 NatHERS ratings data records which were provided for the purpose by CSIRO and Sustainability Victoria.[11] That is, it is expected that up to 10% of new dwelling designs would require some modification in order to comply with the proposed heating and cooling load limits. Again by definition, these will be the 10% of outlier designs that, while complying with the 6 star standard generally, have relatively poor either heating or cooling load performance. This means that excessive energy consumption will be required in one season or the other to maintain thermal comfort. Alternatively, in non-space-conditioned conditions, designs with high heating or cooling loads would experience relatively poor control of internal temperatures in winter and summer respectively.

The TIC research also indicated that while the extent to which the outlier designs exceed the proposed load limits is modest on average (but higher in individual cases), when aggregated nationally, the quantity of energy consumption is reduced (see Section 4). Importantly, the TIC research found that there are options available to address the problem of poor design optimisation

[11] Tony Isaacs & Robert Foster, 2017a, *Principles and methodology for setting NCC heating and cooling load intensity limits & draft heating and cooling load intensity limits for all NatHERS climates*. Tony Isaacs Consulting.

that are simple and modest in impact, and that in most cases will lead to reductions in construction cost. These options are presented in Section 3 and are assessed in Sections 4 and 5 of this RIS.

2.3 Objectives

The aim of this regulatory change is to ensure designs that use the NatHERS compliance pathway minimise the need for heating and cooling in accordance with current Performance Requirement P2.6.1 and JP1, in NCC Volumes Two and One respectively. The specific target of the change is dwelling designs that represent outliers either in terms of excessively high heating load intensity or excessively high cooling load intensity; that is, the 5% of designs with the highest heating/cooling loads in each climate zone. The objective of Options 2 and 3 is that new dwellings are designed in such a way as to deliver adequate standards of thermal comfort and energy performance all year round, thereby improving occupant comfort, containing energy demand, and reducing bills, greenhouse gas emissions and peak loads.

An additional objective of the proposal is to improve the precision and credibility of policy and regulatory instruments. It is important that instruments are designed to best enable the achievement of agreed policy goals. It is also important that policy makers are well equipped to adjust policy settings in the future to realise evolving policy goals in areas such as energy security, contained energy costs, climate damage from greenhouse gas emissions and increasing the average level of health and wellbeing of the community.

3. Options for Addressing the Problem and Meeting Code Objectives

This RIS considers three options:

1. Retaining the status quo (that is, mainly 6 star but no separate heating or cooling load limits)
2. Amending the Code to require those choosing the NatHERS verification path to demonstrate that designs meet separate heating and cooling load limits, depending upon the climate zone, in addition to the current 6 star requirement;
3. Seeking to achieve the outcome of improved heating/cooling load performance via non-regulatory means.

3.1 Option 1 – Status Quo

The status quo for NCC 2019 would involve retaining the requirement, under the NatHERS verification pathway, of achieving 6 stars in general, meaning an annual average thermal load requirement for each climate zone, but no separate heating and cooling load limits. This situation has prevailed since BCA2010, noting that there are dispensations that allow for a lower rating than 6 stars in some circumstances:

- Class 2 dwellings must achieve an average rating across all dwelling units within a development of 6 stars and no individual dwelling unit may have a rating below 5 stars
- NCC climate zones 1 and 2 where dispensations are provided as follows:
    - For dwellings with an outdoor living area as defined in the NCC, a minimum 5.5 star standard
    - For dwellings with an outdoor living area fitted with ceiling fans as defined in the NCC, a minimum 5.0 star standard.

In addition, there are a number of state and territory variations:

- The Northern Territory uses NCC 2009 which sets minimum requirements at 5 stars
- NSW uses BASIX that results in building fabric performance standards down to as low as 4 stars or less but are on average around the 5 star mark, although standards were lifted modestly from July 2017
- In Queensland, Class 2 dwellings are covered by NCC 2009 which requires a minimum 4 stars and an average of 5 stars.

3.2 Option 2: Regulatory Adjustment (moving to separate NatHERS load limits, plus an information/education program)

The second option has two features:

i. *regulatory adjustment to current settings so that separate heating and cooling limits would augment the combined limit in NatHERS.*

The current NatHERS combined limits will remain the metric for determining the energy rating for each climate zone. This feature ensures that the proposed adjustment is not a change to overall stringency. The proposed change is that designs in climate zones that experience both warm and cool weather would additionally have to meet the separate load limits that have been developed by TIC.[12] The new heating and cooling load limits have been developed for several different building types – please refer to the Standard on the ABCB's website. The climate zones that will be exempt from separate heating and cooling load limits are in cool regions (Hobart and alpine areas) along with regions of northern NT, QLD and WA that only experience warm weather and the heating load is less than 5% of total energy load. Climate zones in NSW were modelled by TIC; however, this proposal does not apply to NSW on the grounds that the BASIX scheme – which is a state variation to the NCC that replaces clauses 3.12.0.1 and J0.2 – already requires separate heating and cooling load limits to be applied to new residential building construction work.

ii. *The provision of targeted information and education programs to improve the quality and availability of information in the market. The information program would consist of a set of publicly available educational material, such as advisory notes, handbooks and user guides. The educational material would be backed by a targeted training program for designers, architects, energy assessors and builders.*

It would be possible to make the regulatory adjustment of separate load limits without providing an information and education program. However, as discussed in Sections 2 and 4 of this Report, it is likely that net social benefits would be maximised by undertaking both measures simultaneously. Provision of separate limits within NatHERS regulatory settings would send a clear directive that both heating and cooling loads must be addressed in dwelling designs. The complementary information campaign would aim to increase the sophistication of understanding of thermal load limits and design issues by the most relevant industry participants in the market.

Such a campaign is in accordance with the regulatory best practice principle that regulated parties clearly understand the policy intent of regulation; and have the skills and knowledge to allow them to comply. Further, it would aid those market participants who aim to optimise thermal load performance – those seeking to go beyond compliance.

The information campaign could draw on the work completed by TIC, along with other relevant materials, to highlight the underlying causes of excessive heating or cooling loads, as a joint function of details of design and specification, on the one hand, and climate zone, on the other hand. The

12 The proposed load limits are set out in Appendix 3 of Tony Isaacs & Robert Foster, 2017a

programs would also highlight the range of possible solutions, and the consequences for incremental building costs of those choices.

3.2.1 Implementation

Since the Consultation RIS, further work has been undertaken to specify the implementation details for this option. It is proposed that the Code would be amended such that clause J0.2(a) for Class 2 SOUs and Class 4 parts of a building would require to collectively achieve an average energy rating of not less than 6 stars, *including the separate heating and cooling load limits*, and individually achieve an energy rating of not less than 5 stars, *including the separate heating and cooling load limits.* The limits would be published on the ABCB's website as the *ABCB Standard for NatHERS Heating and Cooling Load Limits*. Similarly, for Class 1 dwellings, clause 3.12.0.1(a) would specify that a building must achieve an energy rating, including the separate heating and cooling load limits…of greater than or equal to 6 stars…, and include a new clause 3.12.0.1(b) specifying that the heating and cooling load limits in (a) are specified in the ABCB Standard for NatHERS Heating and Cooling Load Limits.

The NatHERS Administrator has indicated that if Option 2 were to proceed, they would seek to implement two changes:

1. A separate section will be included at the bottom of the Universal Certificates with text to refer to the NCC for energy efficiency requirements, including separate heating and cooling load limits
2. Software tool developers will include a text prompt in their software alerting assessors to check the calculated heating and cooling loads against the NCC split heating and cooling load limits prior to the UC being generated.

Coverage of the Measure by State/Territory/Climate Zone

The impact of this proposed measure would vary by state and territory and climate zone. First, TIC noted that there would be little or no practical effect in implementing this proposal in climate zones where there is, on average, either no heating load or no cooling load. This is because there is no need to consider the energy performance of housing in the 'opposite' season, as there is effectively no opposite season. TIC therefore proposed excluding Tasmania, the Northern Territory, and climate zones in northern QLD and WA where there is, on average, no or almost no heating load. The climate zones excluded in WA include:

- Port Hedland (CZ 2)
- Wyndham (CZ 30)
- Broome (CZ 33)
- Learmouth (CZ 34)
- Halls Creek (CZ 37).

Referring to the Residential Baseline Study,[13] we note that, in total, these climate zones accounted for 0.32% of all households in Australia in 2006. Assuming that housing distribution has not changed significantly since then, and converting the national share of households into the share of households by state, we obtain an estimate that 2.0% of WA households were located in these climate zones. As a result, we eliminate 2% of the WA housing stock from our model.

Using the same methodology for QLD, we note that the following climate zones are intended to be excluded:

- Longreach (CZ 3)
- Townsville (CZ 5)
- Weipa (CZ 29)
- Willis Island (CZ 31)
- Tennant Creek (CZ 38)
- Cairns (CZ 32)
- Mt Isa (CZ 39).

The above climate zones amount to 2.48% of national households, equivalent to 9.8% of QLD households, and these are excluded from our stock model and benefit cost analysis.

In response to the Consultation RIS, some stakeholders in Victoria noted that the Better Apartments Design Standards (BADS) have applied to apartment developments in Victoria since April 2017, subject to transition arrangements – refer to Planning Advisory Note 66, April 2017. The standards are given effect through Clauses 55.07-1 and 58.03-1 of the Victorian Planning Scheme. These standards call, *inter alia*, for apartments to meet specific maximum cooling load limits. No maximum heating load is specified. A submission from the Council Alliance for a Sustainable Built Environment (CASBE) notes both positive impacts for improved cooling performance and the risk of adverse impacts for heating loads, noting this aspect is not controlled by BADS. We also note that the Victorian measure has not been in place for long and its impact is not clear at this stage.

NSW is excluded from the analysis on the grounds that the BASIX scheme – which is a state variation to the NCC that replaces clauses 3.12.0.1 and J0.2 – already requires separate heating and cooling load caps to be applied to new residential building construction work. Therefore NSW is excluded from analysis.

Finally, in Queensland, the Queensland Development Code allows Class 1 dwellings with an outdoor living area in NCC climate zones 1, 2, 3 and 5 to achieve a star rating of 5.5 stars, and those with an outdoor living area and a permanent ceiling fan or at least 1 kW of solar photovoltaic cells to achieve 5 stars; while in climate zones 1, 2 and 5, a dwelling with an outdoor living area and at least 1 kW of solar PV may achieve 4.5 stars. Class 2 SOUs and Class 4 parts of a building must meet an average

[13] DEWHA, *Energy Use in the Australian Residential Sector, 1986 – 2020, 2008*, prepared by Energy Efficient Strategies, Table 47, pp 126 – 127.

of 5 star and a minimum of 4 stars, as per BCA(2009). The ABCB notes that the ABCB Standard for NatHERS Heating and Cooling Load Limits includes limits for 5 and 5.5 stars, in addition to 6 stars. Data from the NatHERS portal suggests that 21% of new Class 2 dwellings in recent years have rated at less than 5 stars. As a result, the measure would not apply to this segment of the market, and so we reduce the costs and benefits associated with the measure in Qld by this amount.

3.3 Option 3: Information and Education Campaign (promoting voluntary application of separate load limits by the construction industry)

The third option assessed is voluntary uptake of the heating and cooling load limits, encouraged by an information and education program. In this option, a similar industry awareness and education program as for Option 2 would be undertaken, to raise awareness of the need to consider separately heating and cooling performance issues, and to encourage voluntary implementation of the ABCB Standard for NatHERS Heating and Cooling Load Limits. The awareness campaign could be supported by the ABCB, state and territory governments, and industry professional bodies and associations. The education aspects are most likely to be integrated into ongoing continuous professional development programs.

4. Benefit Cost Analysis

4.1 Methodology and Key Assumptions

4.1.1 Overview

Our overall approach to estimating the benefits and costs associated with the potential regulatory and non-regulatory solutions is summarised as follows:

1. The measure is assumed to apply for 10 years (FY2019/2020 to FY2028/2029), and then be subject to regulatory review. This means that no new costs or benefits are assumed to occur after FY2028/2029.
2. Energy savings (in MJ/m^2.year) for changed designs are taken from TIC, by climate zone and housing type – these are assumed to take effect from May 2019, with FY2019/20 being the first full year of savings.
3. The unit savings above are aggregated up to the national level (resolved by affected state/territory) using a housing stock turnover model, with projections to 2060 [14] (assuming a 40-year economic life for dwellings), with the key assumption that 5% of the new stock is modified for heating performance and 5% is modified for cooling performance. Savings occur in the new stock added over a 10-year period from FY2019/2020 to FY2028/2029, with savings persisting over the 40 years (cut off at 2060).
4. The value of energy savings is estimated using projections of electricity prices sourced from the Australian Energy Markets Operator (to 2037) and assumed constant in real terms thereafter (as noted below, we assume new dwellings will generally use electricity for space conditioning).
5. For the non-regulatory option, we apply an estimated take-up percentage; for the regulatory option we assume the take-up is 100%.
6. External benefits – shadow carbon prices and avoided network costs – are added, and total benefits summed, as detailed below.
7. Costs are estimated in two categories: first, substantive compliance costs, which are the additional costs (if any) of modifying the designs as above, incurred by house owners. Substantive compliance costs are estimated for all potential solutions (as identified by TIC), as detailed in Appendix A, and assigned to 'least cost', 'highest cost' and 'average cost' buckets for analytical purposes. Second, information/education costs, including costs to government and industry (time for participation in training/reading of materials, and possible one-off redesign costs), are summed to estimate total costs. Information/education

[14] The measure is assumed to apply from FY2020 to FY2029, and no new dwellings are assumed to be affected after then. However, benefits are calculated over the economic life of the buildings impacted, which extends to around FY2060.

costs are estimated top-down and are intended to represent likely costs incurred by state/territory governments (or the ABCB) in providing information/education products to industry and the wider public. Costs are assumed to be incurred for up to 10 years (FY2019/2020 to FY2028/2029), when a regulatory sunset clause or review is assumed to occur.

8. Using a default real discount rate of 7%, we then sum the present value of total benefits and the present value of total costs; and calculate the net present values (difference between the present value of benefits and costs), by state/territory and total.
9. Finally, we conduct a number of sensitivity analyses and report our findings.

> We note that one stakeholder suggested that the time horizon for analysis could be shortened in line with the 3-yearly review cycles of the Code. A 10-year timeframe for analysis is required by the Office of Best Practice Regulation unless it agrees otherwise, for example if an intervention is intended to be short term.

The following sections provide further details on these key steps and assumptions. Note that all the analysis is carried out in real FY2018 dollars.

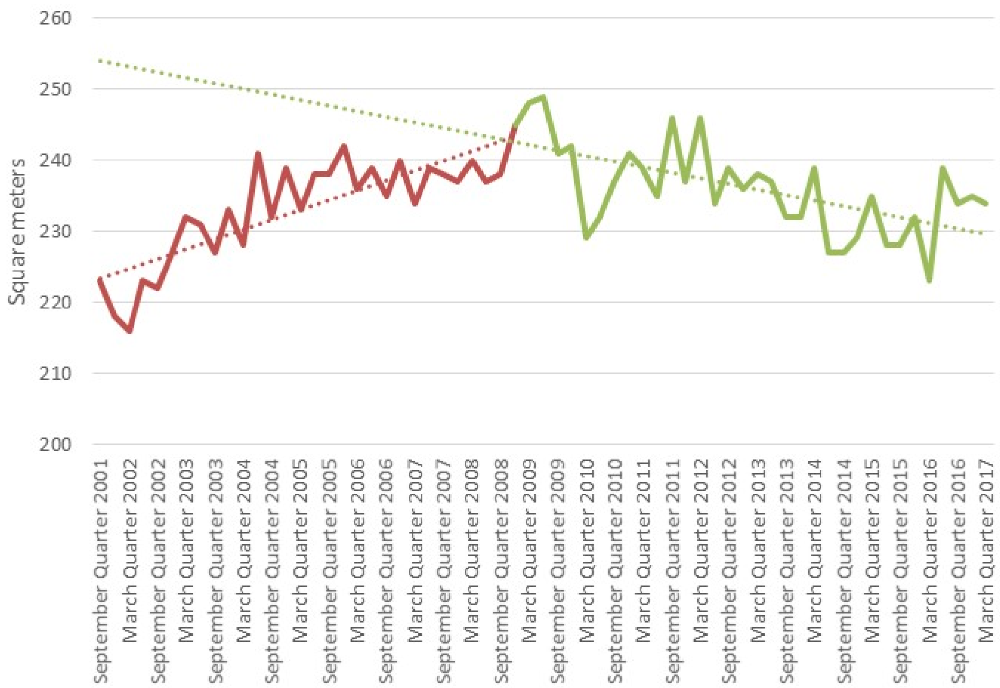
4.1.2 Building Stock Turnover Modelling Assumptions

The expected area (in square meters) of 'new building work' undertaken annually, from FY2019/2020 to FY2059/2060[15], is modelled based on ABS building completions data for Class 1 ('houses') and Class 2[16] ('other residential').

Historical data is published quarterly, by state and territory and total. We estimate the total square meters completed in 2016-17 by multiplying the number of completions (Australia) in this year by the average dwelling size of completions over the same period, for each of Class 1 and Class 2. Dwelling size data is not routinely published by the ABS, but is available for purchase as a 'customised table' – see Figure 1 and Figure 2. We note that the trend towards increasing average dwelling size in the 2000s appears to have been replaced by a trend towards declining average sizes – for both Class 1 and Class 2 dwellings, although the change is more marked for Class 1 dwellings. Whether these changes will be sustained in future is moot.[17]

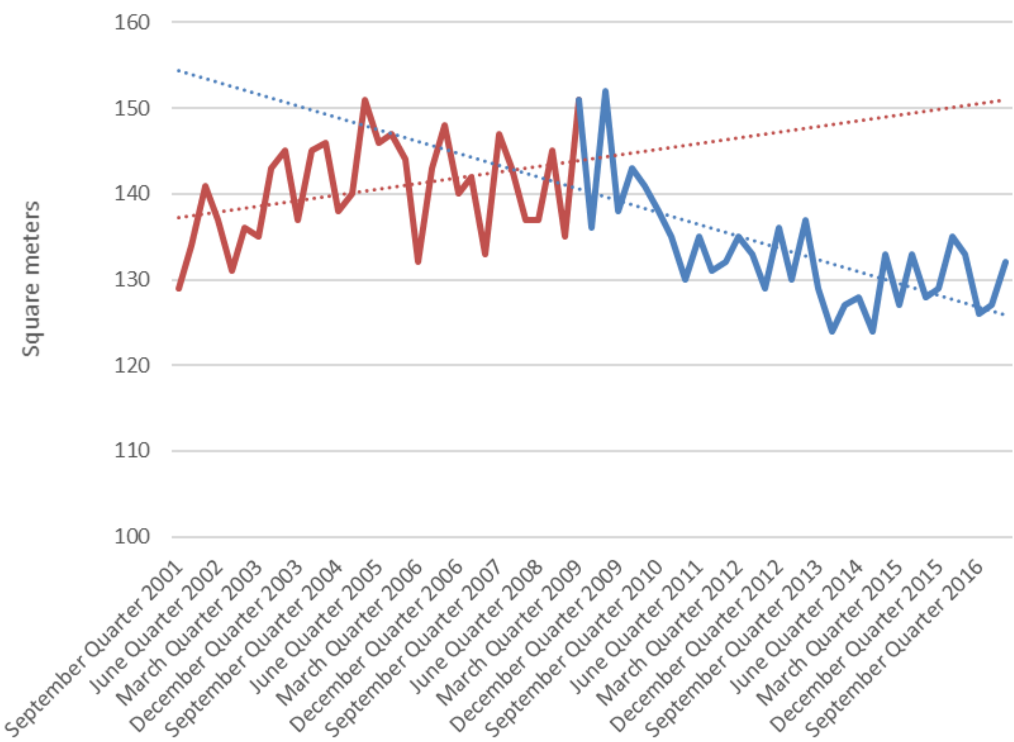
[15] Since the measure is assumed to apply over the FY2019/2020 – FY2028/2029 period, this is the only segment of the stock model that is relevant for this project.
[16] For the purpose of benefit cost analysis, Class 2 represents Class 2 SOUs. The number of Class 4 parts of a building is fairly small, hence the analysis focuses on Class 2 SOUs.
[17] Note that our stock model methodology makes no explicit assumptions about future average dwelling sizes. We model stock growth in square meters, not in dwelling numbers and sizes, with future growth assumptions linked to ABS projections regarding the expected rates of formation of different household types.

Figure 1: Average Size of Class 1 Completions, Australia, 2001 - 2017



Source: ABS Building Activity Customised Report, 2017

Figure 2: Average Size of Class 2 Completions, Australia, 2001 - 2017



Source: ABS Building Activity Customised Report, 2017

After discussion with the ABCB, we removed allowances for alterations and additions, including major renovations, on the grounds that the majority of these are likely to demonstrate compliance via another deemed-to-satisfy (DTS) path rather than NatHERS.

Also, the ABS completions data is not well aligned with the NCC and NatHERS in at least two respects. First, the observations of average floor area are based on a gross floor area metric, which measures floor area from the outside of the exterior walls, while the area under unenclosed verandahs, carports, etc., is excluded, while garages, wet areas (bathrooms, laundries, toilets) are included. [18] The latter areas are generally not space conditioned, and therefore do not fall within the scope of NatHERS. We made an allowance of 5% of the gross floor area for walls and, drawing on data of standard residential dwellings, allowed 15 sqm for wet areas and 38 sqm for garages, for an average Class 1 dwelling, and 13.5 sqm for wet areas and 24 sqm for carparking (generally under-croft or underground) for an average Class 2 dwelling. Applying these assumptions (to the national average size of completions as observed by the ABS), we assume that 72.4% of the gross floor area of Class 1 dwellings in conditioned, while 66.4% of Class 2 gross floor area is space conditioned. When compared to earlier analyses, these assumptions reduce both costs and benefits by broadly the same proportions.

Second, the completions data resolves 'houses' (defined as 'a detached building predominantly used for long-term residential purposes and consisting of only one dwelling unit') and 'other residential buildings' ('a building which is predominantly used for long-term residential purposes and which contains (or has attached to it) more than one dwelling unit (e.g., includes townhouses, duplexes, apartment buildings, etc.).[19] The first category corresponds with NCC Class 1a(i) (detached dwellings), while the second rolls together at least Class 1a(ii) (semi-detached) and Class 2 (apartments). Class 4 parts of buildings (e.g., caretakers' residences) may appear as 'houses' in the ABS data, however, this is a very minor Class and not material to the analysis.

Since the Consultation RIS, we have updated our estimate of the share Class 1a(ii) dwellings by drawing on new data from the 2016 Census, which indicates that, nationally, 13.1% of dwellings in that year were semi-detached, as compared to the estimated previously used from the NEXIS database, which put this value at 5.4% of the housing stock.[20] Therefore in our stock model, we transferred 13.1% of the total residential gross floor area completed from the 'other residential' category to 'houses', in order to better align these two categories with Class 1 (both detached and semi-detached) and Class 2. When compared to the Consultation RIS, this has the effect of indicating more Class 1 and less Class 2 completions in future.

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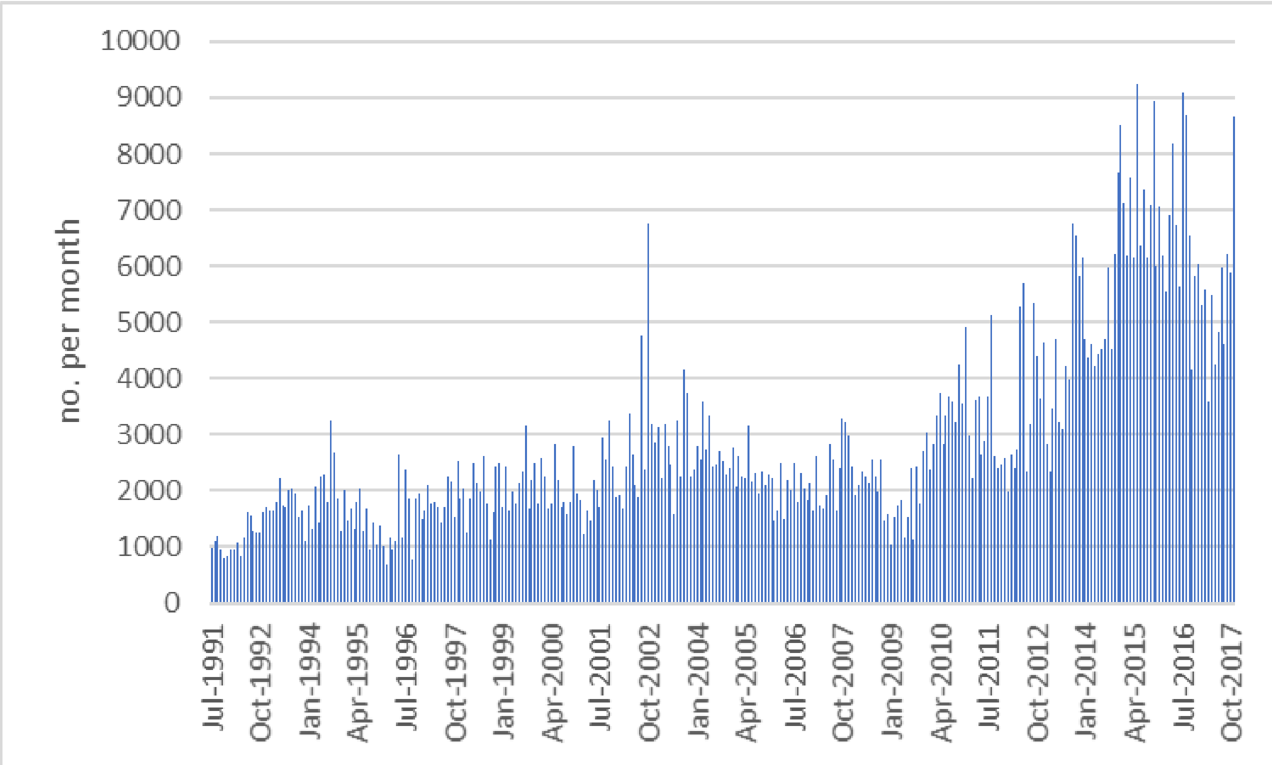
18 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8750.0Explanatory%20Notes1Mar%202002?OpenDocument, viewed 8/2/2018.

19 Ibid.

20 Calculated from Geoscience Australia's NEXIS database, available from http://www.ga.gov.au/scientific-topics/hazards/risk-and-impact/nexis

The recent growth in Class 2 approvals is highlighted in Figure 3. Most commentators expect this general trend to continue, at least in the major cities, and with the normal proviso that building activity is cyclical and subject to unexpected (or at least not forecast) downturns.

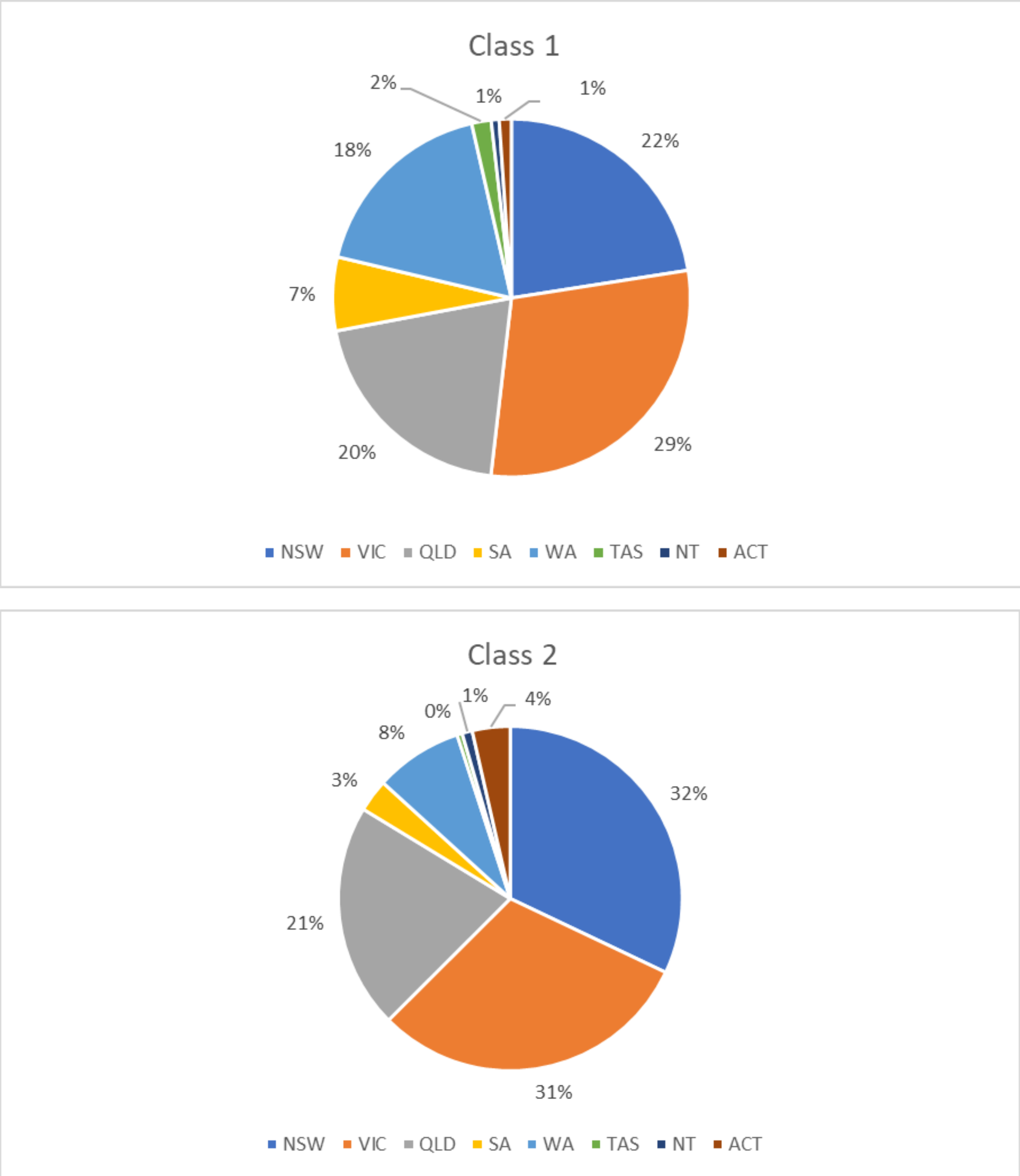
Figure 3: Total Number of New Apartment Dwelling Unit Approvals by Month, 1991 – 2017, Australia



Source: Australian Bureau of Statistics, *8731.0 Building Approvals Australia, Table 20. Number of Dwelling Units Approved in New Residential Buildings, Original – Australia*, Commonwealth of Australia, 2017

The floor area growth is split by state and based on the average shares of completions by state and territory over the last 3 years (that is, the state shares are assumed to remain constant over time) – see Figure 4.

Figure 4: Shares of Class 1 and Class 2 Completions by State and Territory, 3 years to September 2017



Source: ABS: 8752.0, Building Activity, Australia, Table 39

A summary of the projected future completions, including dwelling numbers and floor area by dwelling type, is provided at Table 3. Since the Consultation RIS, the proportion of semi-detached completions has been updated to reflect data from the 2016 Census, which indicates that separate houses represented 72.5% of occupied dwellings in that year, semi-detached 13.1% and apartments 14.4%. This represents an increase in the share of semi-detached dwellings previously used, of 5.5%, which was sourced from Geoscience Australia's NEXIS database. The effect of this change is that we show higher Class 1 and lower Class 2 completions than in the Consultation RIS.

Table 3: Projections of Completions and Floor Area Built to Code, FY2017 – FY2029

Financial Year	Class 1 Completions	Class 1 Floor Area Built to Code	Class 2 Completions	Class 2 Floor Area Built to Code	Total Completions	Total Floor Area Built to Code
2017	162,096	32,851,024	54,340	7,118,535	216,436	39,969,559
2018	164,970	33,433,572	55,518	7,272,918	220,489	40,706,490
2019	167,844	34,015,830	56,716	7,429,797	224,560	41,445,628
2020	170,737	34,602,332	57,927	7,588,466	228,665	42,190,798
2021	173,574	35,177,144	59,155	7,749,369	232,729	42,926,513
2022	176,353	35,740,319	60,418	7,914,734	236,770	43,655,053
2023	179,133	36,303,730	61,668	8,078,459	240,800	44,382,189
2024	181,905	36,865,571	62,934	8,244,380	244,839	45,109,951
2025	184,688	37,429,550	64,211	8,411,689	248,899	45,841,239
2026	187,445	37,988,296	65,514	8,582,274	252,958	46,570,570
2027	190,128	38,532,000	66,844	8,756,620	256,972	47,288,620
2028	192,819	39,077,491	68,158	8,928,666	260,977	48,006,157
2029	195,498	39,620,445	69,463	9,099,607	264,961	48,720,052

Section 6 notes that one stakeholder felt the assumptions used for building completions were unreasonable while others did not express an opinion. Since the Consultation RIS, the estimated number of building completions has been reapportioned to better reflect the share of Class 1 and Class 2 buildings.

4.1.3 Energy Savings/Fuel Mix

Energy Savings

As noted, energy savings associated with the proposed regulatory change have been calculated with some precision by TIC, and are employed here. On average the annual heating energy savings are 2.5 MJ per square metre. Average annual cooling energy savings are 4.3 MJ per square metre[21]. As per TIC's methodology, we assume that 5% of the new housing stock would require some amendment to meet the proposed heating load limits, and 5% would require amendment to meet the proposed cooling load limit. Total energy savings are therefore:

> *[annual additions to stock in sqm] * 5% * [modelled reduction in heating load + modelled reduction in cooling load] / [average co-efficient of performance (COP) of space conditioning appliances].*

TIC modelled a range of dwelling designs in 10 representative climate zones around Australia. TIC's choice of climate zones includes considerations of the housing growth areas, as well as a requirement to cover capital cities. In the case of NSW, the climate zones of Richmond (CZ 28) and Sydney (CZ 17) are modelled (the latter for Class 2 dwellings only – but noting that NSW results are

[21] Isaacs, Tony & Foster, Robert, 2017b, *The impact of heating and cooling load intensity limits on NCC compliance.* Tony Isaacs Consulting for the Australian Building Codes Board.p.3

removed from the analysis in any case). In the case of Victoria, observations are made for Mildura (CZ 27) and Melbourne (CZ 21 – Class 2 only)/Tullamarine (CZ 60 – Class 1). In our savings estimates and also compliance costings, these latter Victorian regions are weighted 50/50.

TIC modelled Class 1 dwellings with slab or timber floor types. Our benefit cost model defaults to savings estimates that are a simple average of these two, but either floor type can be selected for sensitivity analysis purposes (see Section 4.3.2 below).

Fuel Mix

We make the assumption for this analysis that a significant majority of new houses and apartments in Australia will use electricity as their sole energy source for space conditioning. The rationale for this reflects:

- The increasing use of electrical heat pumps for both space heating and cooling - around one million refrigerative air conditioners are sold in Australia per year, with an estimated stock of almost 12 million in 2014.[22]
- The continuing rise in the efficiency (co-efficient of performance, or COP) of electrical heat pumps.[23]
- A growing awareness of the cost savings associated with streamlining the number of energy connections, and of fuel switching from gas to electricity.[24]

While some households will no doubt choose to install gas space heating – reflecting local trends and habits, inter alia – the effect of this 'all electrical' assumption is to make the estimate of energy savings more conservative. This is because electrical heat pumps require less energy consumption than gas heaters to meet a given space heating load.

Co-efficient of Performance (COP)

The average COP assumptions are shown below, and represent sales weighted averages of projected sales in 2020 and 2030 (projections provided by the Department of the Environment and Energy). COPs were projected for individual equipment types, but not sales-weighted averages, for 2040 and 2050, and we have applied the 2030 weightings to these values. Also, the Departmental assumptions only included observations at 10-year intervals, to 2050, so we have filled in the intervening years by linear interpolation, and also extended the series to 2060 (to fit our model timeframe), again by linear extension.

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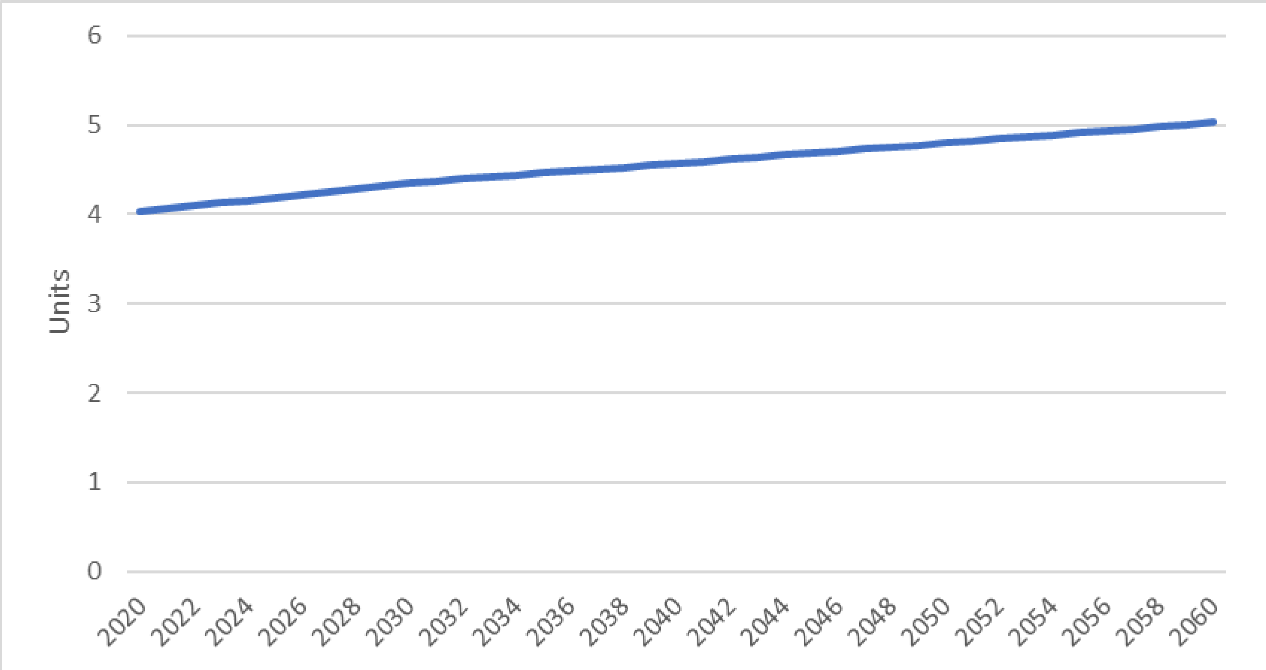
[22] E3 Equipment Energy Efficiency, *Consultation Regulation Impact Statement – Air Conditioners and Chillers*, February 2016, p. v.
[23] See, for example, Heat pumps - radical efficiency by moving energy, viewed 31/10/2017.
[24] See, for example, Heat pump tech could save Victorian homes up to $658yr on gas, viewed 31/10/2017.

Figure 5: Average COP Assumptions (Expected Sales Weighted Averages)



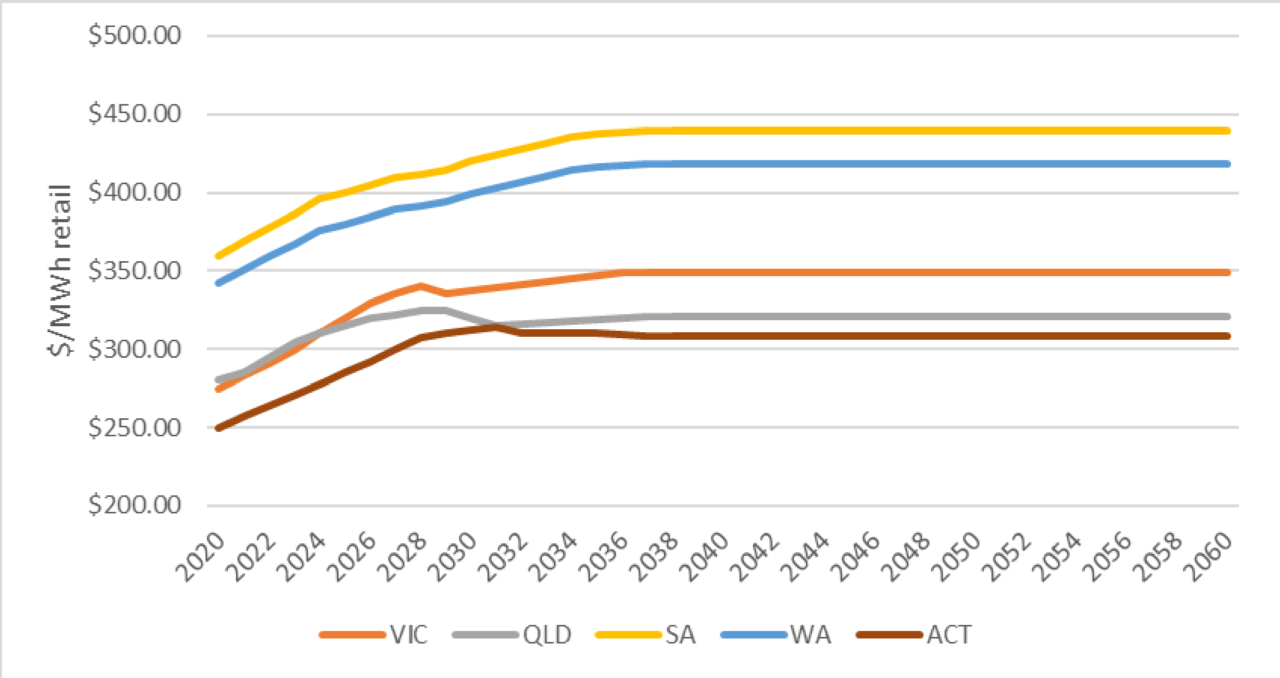
Source: Department of the Environment & Energy

4.1.4 Value of Energy Savings/Energy Prices

The value of avoided energy costs is represented by the volume of energy savings, as calculated above, in each time period multiplied by a projected residential retail electricity price. Price projections over the 2020 – 2037 period are sourced from the Australian Energy Markets Operator's *National Electricity Forecasting Report 2016*, and assumed to remain constant (in real terms) thereafter (see Figure 6 below). Note that WA and NT are not part of the National Electricity Market (NEM), and therefore not included in this source. We assume that WA prices average 95% of those in SA over time,[25] while NT prices are not material, as they are not proposed to be covered by the potential regulatory change (effectively there is no heating load in the NT, so separating heating and cooling load limits make no sense).

[25] See, for example, relative prices in *Australian Energy Market Commission, 2017 Residential Electricity Price Trends Final Report*, December 2017, Figure F1 (p.131) for SA and Figure H1 (p.153) for WA.

Figure 6: Electricity Price Projections by (Selected) State/Territory, FY2019/2020 – FY2059/2060



Source: derived from AEMO, National Electricity Forecasting Report 2016, Figure 10

As is much in the news at the moment, there is very considerable uncertainty about future electricity prices and, indeed, a wide range of prices paid by different users as a function of their size, load characteristics, location, retailer, tariff structure, etc. While it would be conventional to apply sensitivity analysis to energy price considerations, in this case, the Benefit Cost Analysis (BCA) results reported below are such that such sensitivity analysis would not be material. This is because the analysis is driven by the cost side of the equation, rather than benefits, while energy prices affect the value of benefits.

A final issue to note is the choice of retail prices to represent the value of avoided electricity costs. Some analysts, and indeed some states (at least NSW), prefer to use wholesale prices, or other constructs such as long run marginal cost or avoidable costs to represent the (net) value of energy savings. The apparent rationale is the view that the network component of electricity prices is not avoidable, therefore, if electricity savings are made, the revenue foregone by network businesses simply gets added to future network tariffs and distributed across future consumers.

However, network costs are 'sticky' rather than fully unavoidable. The Australian Energy Regulator can reduce, and indeed has been very actively reducing in recent years, network charges, as a delayed response to inflated demand growth and related cost growth projections by networks. As with virtually all businesses, when projected demand fails to materialise, network revenues can indeed fall and fall sharply. In effect, network costs are avoidable *with a lag*. The length of the lag would depend upon the sharpness of regulatory oversight, but would be unlikely to exceed 2 – 3 years, and such delays will rarely be material in the context of long-term social benefit cost analysis.

4.1.5 Avoided Climate Damage Costs

The production and consumption of electricity in Australia is, to varying degrees by state and territory, associated with the release of damaging greenhouse gas emissions. These emissions are not currently priced in markets, and therefore represent an external, or socialised, cost. In principle, benefit cost analysis should aim to reflect the avoided costs of future climate damage – however, there is significant uncertainty about the incidence and timing of damage costs associated with future climate change. Some research is being conducted into what is known as the 'social cost of carbon'. The Intergovernmental Panel on Climate Change has noted, for example:[26]

> *Aggregate economic losses accelerate with increasing temperature (limited evidence, high agreement), but global economic impacts from climate change are currently difficult to estimate. With recognized limitations, the existing incomplete estimates of global annual economic losses for warming of ~2.5°C above pre-industrial levels are 0.2 to 2.0% of income (medium evidence, medium agreement). Changes in population, age structure, income, technology, relative prices, lifestyle, regulation and governance are projected to have relatively larger impacts than climate change, for most economic sectors (medium evidence, high agreement). More severe and/or frequent weather hazards are projected to increase disaster-related losses and loss variability, posing challenges for affordable insurance, particularly in developing countries. International dimensions such as trade and relations among states are also important for understanding the risks of climate change at regional scales".*

Given this uncertainty, most analysts use observations of a 'shadow price' for carbon, based generally on countries with carbon trading schemes, as a proxy for climate change damage costs. Arguably, such shadow prices structurally undervalue avoided damage costs, as carbon market participants are responding primarily to short term market drivers, such as the manner in which policy and regulatory frameworks influence the demand for and supply of carbon 'units'. These factors and resulting prices may carry very little information about expected future damage costs.

However, consistent with current regulatory practice, we include observations of shadow carbon prices as modelled by ACIL Allen in the context of the Climate Change Authority's 2013 *Targets and Progress Review*.[27] While these values date from 2013, the Australian Government has not updated these values since, and indeed they remain the consultant's assumptions, rather than officially-endorsed values. We use the 'central policy scenario' as the default option, extending the values to 2060 by linear extension, and examine other scenarios in sensitivity analysis. We note that this scenario suggests lower values than those used by Energy Networks Australia and CSIRO for their *Electricity Network Transformation Roadmap* – which uses values closer to the 'high carbon price' scenario below.[28]

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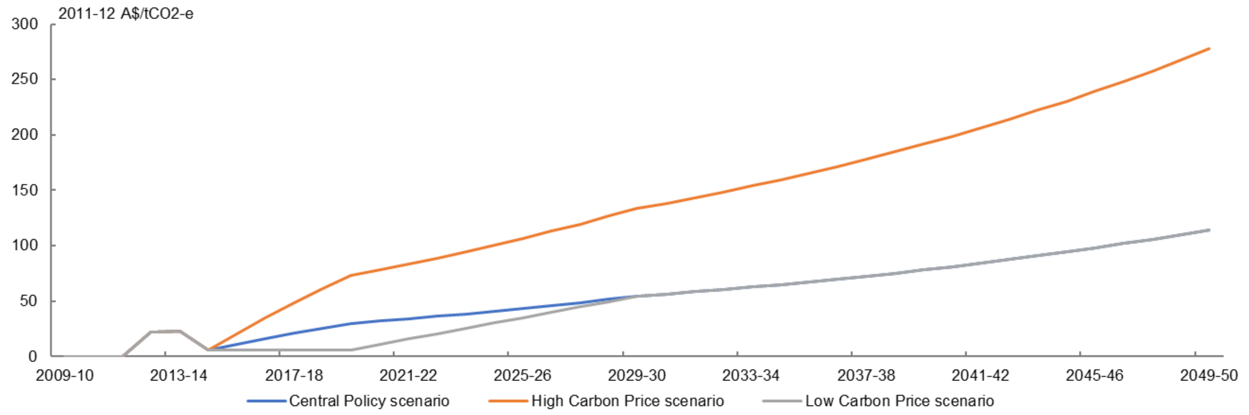
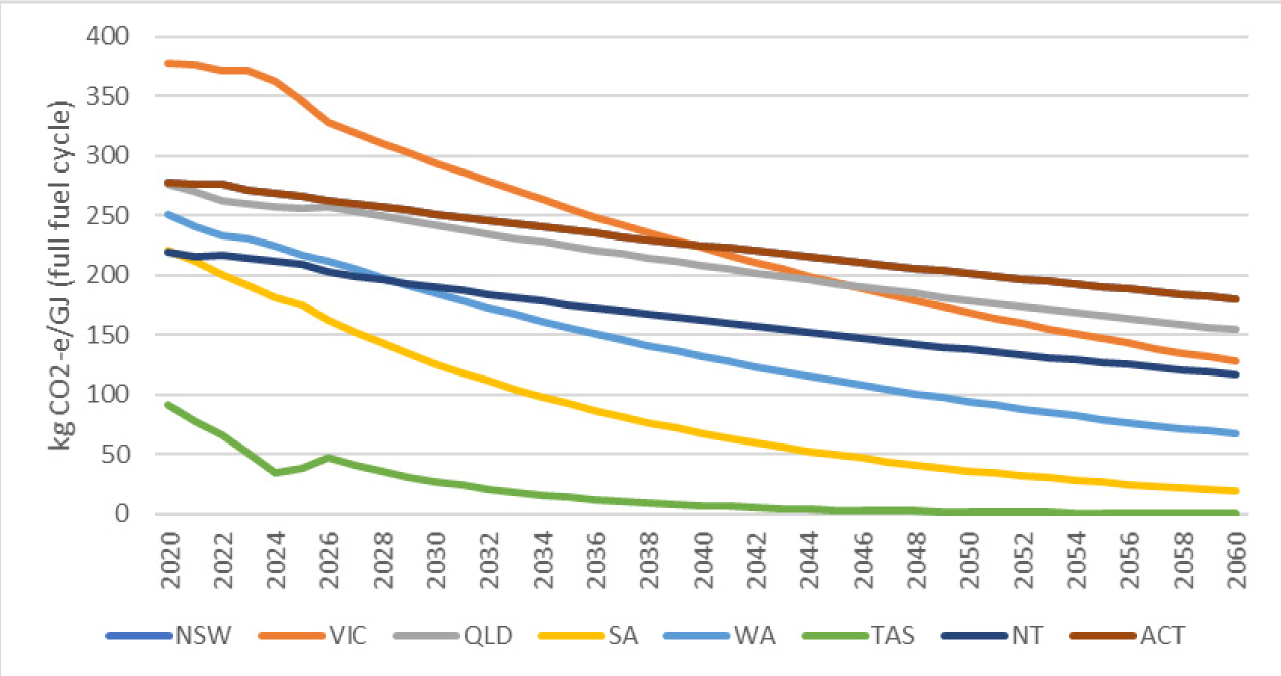
[26] IPCC, *5th Assessment Report: Synthesis for Policy Makers*, 2014, p. 73.
[27] Targets and Progress Review, viewed 31/10/2017.
[28] Electricity Networks Australia and CSIRO, *Electricity Network Transformation Roadmap, Future Grid Forum – 2015 Refresh, Technical Report*, 2015.

Figure 7: Shadow Carbon Price Scenarios



As these prices are denominated in tonnes of CO2-e, then it is necessary to project and apply greenhouse intensity of electricity supply observations, by state and territory, to 2060. As with electricity prices, these values are also highly uncertain, and will vary as a function of many factors including relative fuel prices, technology prices and many policies and measures. As a pragmatic response to this uncertainty, we calculate the average annual change in emissions intensity of electricity consumption by state over the 2010 – 2016 period (as observed in the National Greenhouse Accounts Factors Workbook 2017), and apply this same value for future periods. The resulting projection is as shown in Figure 8 below.

Figure 8: GHG Intensity of Electricity Consumption Projections by State/Territory



4.1.6 Avoided Electricity Network Costs

While the potential changes modelled are small, they would lead to reduced demand growth at the margin for networks, particularly at either winter or summer peaks. Since network costs are spread across all (or many) consumers, individual consumers that take actions to that reduce network costs (such as those envisaged in this regulatory proposal) are not appropriately compensated; that is, they created an 'externalised' benefit that forms part of the net social benefit associated with the action.

It is important to note that this effect is different from the avoided energy cost, as discussed above. The avoided retail cost includes a component which represents the (estimated) cost of providing current network infrastructure. However, this effect estimates the avoided need to expand or reinforce the network in future.

To value network savings, we draw on analysis conducted by the Institute for Sustainable Future and Energetics in a report prepared for the Department of Climate Change and Energy Efficiency, and is known as the Conservation Load Factor (CLF) method.[29]

Input values including the CLF were informed by two additional references by Oakley Greenwood/Marchment Hill[30] and SKM MMA.[31] The reduction in energy that is attributable to avoided network costs is calculated based on the following formula:

$$\text{Peak demand reduction}^{i}_{\text{Summer, Winter}} = \frac{\dfrac{\text{Annual energy usage reduction}^{i}_{\text{jurisdiction}}}{8{,}760\ \text{h}}}{\text{CLF}^{i}_{\text{Summer, Winter}}}$$

Rearranging the above formula, the Conversion Load Factor (CLF) for a specific energy saving technology is defined as "…its average reduction in load divided by its peak reduction in load (annual energy savings in MWh divided by number of hours per year divided by system co-incident peak reduction (in MW)". [32]

The calculation of avoided network and electricity system infrastructure as a consequence of an improvement in energy efficiency is a complex calculation, potentially affected by many factors. SKM note:

> *Due to…complexities discussed [in its Report], there is no definitive approach to produce a value per kW of peak demand reduction. Depending on the timing and location in the network, the value can vary from zero up to several times the average capacity cost, with large project deferral values tending to lie within this range. (p. 33)*

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[29] Institute for Sustainable Future and Energetics, *Building our savings: Reduced infrastructure costs from improving building energy efficiency*, report prepared for the Department of Climate Change and Energy Efficiency, July 2010.

[30] Oakley Greenwood/Marchment Hill, *Stocktake and Assessment of Energy Efficiency Policies and Programs that Impact or Seek to Integrate with the NEM: Stage 2 Report*, August 2012.

[31] SKM/MMA, *Energy Market Modelling of National Energy Savings Initiative Scheme – Assumptions Report*, December 2011.

[32] Oakley Greenwood/Marchment Hill (2012), p. 41.

The Conversion Load Factor (CLF) used here is 0.4, which is chosen as a conservative value for space conditioning end uses, as indicated in Oakley Greenwood et al (pp. 71-71). The avoided networks cost savings are then calculated as a multiple of the peak demand reduction and the average value of electricity infrastructure savings:

> *Avoided network expenditure = Peak demand reduction x average value of electricity infrastructure savings*

Average values for network expenditure by state are sourced from ISF and escalated from 2010 values to 2017 real dollars at 3% per year, and range between $455,000/MW in Western Australia and $849,000/MW in South Australia. We note that higher values are found in the literature cited above. SKM cites a value of $2.44 million/MW for South Australia (p. 34), but notes that this value was derived using 5-year proposed system augmentation capital expenditure estimates and, as such, could be biased upwards. The more conservative value used here reflects past feedback from network businesses, who note that overall network expenditure has slowly markedly in recent years, due to levelling or even declining demand.

4.1.7 Costs

Compliance Costs

Compliance costs are estimated for all potential solutions (as identified by TIC/ESS), as detailed in Appendix A, and assigned to 'least cost', 'highest cost' and 'average cost' buckets for analytical purposes. Appendix A reveals that the range of strategies that may be used to remedy the small percentage of outlier designs, and associated costs, is wide, ranging from cost saving, to cost neutral, to cost positive cost options. Note that where we find construction cost savings for some solutions, these are described as negative costs. Where more than one strategy has a negative cost, the lower of these is denoted the 'least' cost. In some cases, where all strategies have positive costs, then the 'least cost' solution will have a positive cost.

We emphasise that the terms least, average and highest cost refer only to *the solutions identified by TIC.* It is possible that other strategies could be used and that these might have lower or higher costs than those identified. However, TIC/ESS identify generally three, and sometimes five or six strategies, on a wide range of designs, forms and climate zones, and we have costed them all[33], so it is likely that the cost boundaries we identify realistically bracket the range of costs likely to be experienced for most designs. The implications of this range of costs is discussed below – see Sections 4.3.2.

We apply no learning rate, or change in real costs over time, primarily because most scenarios involve negative compliance costs (net construction cost savings), and also because of the minor nature of the changes involved.

[33] Except in cases such as where are different block orientation is recommended – this may not be a practical solution once a development is in train.

The Consultation RIS asked whether the least-cost solutions were considered viable. The majority of submissions indicate that the least cost options are viable. 15 indicated 'yes' or 'generally', with qualifications noted below. 12 provided no response or 'not able to verify'. 3 indicated 'no', and 3 more expressed concerns about least cost solutions being implemented. Specific points included:

- Some solutions named – like improved house orientation – are best dealt with through planning schemes
- Concern about the practicality or acceptability to clients of changing glazed areas, floor treatments or roof/frame/window colours – due to aesthetic preferences of clients or builders, particularly for high-end projects, while project home builders are more likely to adopt least-cost approaches
- Industry professionals may fail to understand the significance of these design/specification elements, and not be able to explain them to clients, suggesting an important need for industry education and awareness-raising
- Many qualified their 'yes' response with provisos such as "as long as it doesn't interfere with a style or marketing position that a company has"
- Some submissions noted that early assessments will increase the likelihood of least cost options
- One submission noted that least-cost outcomes should be understood from the consumer's perspective and not the builder's
- The practical point was made that some ratings tools do not resolve all of the solutions suggested by TIC, including changing window frame colours.

It is important to recall that the examples of solutions identified by TIC are indicative only and not intended to comprehensive or applicable in all circumstances. Heating and cooling load limits would, if implemented, be performance-based requirements, with designers free to propose a wide range of solutions.

TIC has advised that new versions of the ratings tools will include a wider colour palette. In any case, exact colour matching is not necessary – a similar colour with the same reflectance will lead to a correct rating result.

Stakeholders' observations that the issues involved may not be well understood, either by industry or by consumers, and also could in some cases conflict with consumer preferences and existing industry practices, are important and discussed further in Section 4.3.2. These points confirm the importance of industry education and awareness-raising. Two submissions stated, and others suggested indirectly, that uptake of education opportunities is likely to be greater in the presence of a regulatory driver.

Stakeholder comments to the effect that these issues may be seen as low-priority, discretionary or subject to 'style or marketing position' imply that implementation of the measure on a voluntary basis is likely to be limited, including due to aesthetic or design preferences. The practical effect of regulation may be to require designers to understand and then explain to their clients the consequences of certain design or specification choices (where they would lead to heating or cooling load limits being exceeded), and then to identify solutions that are compliant preferred by the client. In the absence of a regulatory driver, there would be little incentive for professionals to make themselves aware of the issues and solutions or to hold such conversations with their clients. A degree of uptake on a voluntary basis is assumed, noting that reductions in construction costs may be available.

Administration Costs (incl. information and training)

Administration costs have been estimated as the costs associated with preparing information resources for web distribution. Such costs may fall on the ABCB, the NatHERS Administrator, and or state and territory governments. The cost allowance also includes materials for inclusion in education and continuous professional development courses, to educate building industry professionals, including energy assessors and compliance officers, about the consequences of different design and specification choices on housing energy performance, and about the regulatory requirements. We assume that the information/education program is sustained for at least three years, in order to maximise the uptake and use of this information in building practice.

The incremental costs of preparation of information/teaching materials is estimated, and notionally allocated by state/territory (excluding NT, TAS and NSW) as shown in Table 4 below. This notional allocation is necessary to complete benefit-cost analysis by jurisdiction, but in reality some of the costs may be incurred by the Australian Government. We would expect costs to include:

- Commissioning (or in-house preparation) of training and educational materials
- Incremental costs associated with publishing/distributing these materials
- Labour time and possible direct costs associated with development and delivery of new CPD modules
- Labour time in following up with RTOs and other organisations to ensure take-up and implementation of education/training programs based on materials developed.

The NatHERS Administrator was asked whether additional costs might be incurred by them, and an allowance of around $100,000 has been made, in addition to the $600,000 estimated for the preparation of training and teaching material, for potential minor software upgrades (noted in Section 3.2) to alter the Universal Certificate and to include a text prompt in rating software to remind assessors to check the calculated heating and cooling loads against the NCC heating and cooling load limits prior to the UC being generated.

Table 4: Estimated Information/Education Costs ($'000)

Jurisdiction	2020	2021	2022
VIC	$180.0	$180.0	$180.0
QLD	$180.0	$180.0	$180.0
SA	$120.0	$120.0	$120.0
WA	$140.0	$140.0	$140.0
ACT	$80.0	$80.0	$80.0
Total	**$700.0**	**$700.0**	**$700.0**

Other Costs to Industry

Consistent with the Australian Government's *Regulatory Burden Measurement Framework*, we estimate possible incremental costs, additional to the compliance and administration costs. The Framework makes it clear that only costs that are 'over and above what a normally efficient business would pay in the absence of the [proposed] regulation' should be included.[34] From this perspective, training and education costs are already incurred by building professional, generally in the context of continuous professional development (CPD) requirements. As the training and awareness raising about separate heating and cooling load limits is very likely to form part of CPD training, there may be no incremental costs for participants. However, to make our analysis more conservative, we include a cost of training time allowance below. We note that unaccredited energy assessors are allowed to operate in some states, and some of these may participate neither in CPD courses or other training opportunities.

Similarly for energy assessment, costs are already incurred (by the home owner) when the NatHERS pathway is chosen. Therefore we only make allowance for possible *additional* assessment costs that may be attributable to the regulatory proposal.

Following confirmation from the ABCB that Option 2 would be implemented by way of an ABCB Standard, as discussed above, additional time costs have been allowed for both assessors and building surveyors to look up the standard online and confirm that the heating and cooling loads comply with Code requirements.

Cost of Training/Awareness-Raising Time

As noted, there could be additional costs to industry associated with reading and understanding training and information materials, and attending training/awareness workshops or seminars. Under the voluntary option, these time costs are not counted as they are assumed to be voluntarily incurred.

While only NSW and TAS appear to have mandatory Continuing Professional Development (CPD) requirements, as a condition for renewing registration and licencing for building professionals, most states and territories, and professional bodies, strongly encourage regular CPD. It is most likely that awareness raising/training about this proposed measure would occur in the context of CPD courses, which many professionals will attend in any case. Rather than CPD courses or time (or points) being expanded, in the wake of this measure, it is more likely that other content may be displaced and replaced with material relating to this issue. Therefore there may be no additional time commitment or cost required.

In the Consultation RIS, we assumed that around 25,000 industry professionals might be trained, with a time commitment of 2 hours each. However, feedback from the NatHERS Administrator suggests that the number of persons likely to require training may be much lower (around 4,000 persons) and that 1 hour of training would suffice. Taking this advice on board, we nevertheless allow for up to 6,000 persons to be trained (noting that some professionals who are not energy assessors or surveyors may elect to undertake the training) for 1 hour each over the 3-year period during which training materials are assumed to be offered by government. That is, one-third of this

[34] Australian Government Department of the Prime Minister and Cabinet, Guidance Note: Regulatory Burden Measurement Framework, February 2016, p. 4.

cost is assumed to be incurred in each of FY2020 – FY2022. As noted above, it is likely that this figure may over-estimate actual incremental costs due to ongoing CPD participation that means that some part of this time cost will be incurred even without this measure. We distribute these costs evenly between Class 1 and Class 2 designs, to ensure that the analysis of the two classes is consistent. Total training time costs for industry are $636,000 in each of FY2020 – FY2022.

Incremental Energy Assessment or Redesign Costs

The Consultation RIS asked stakeholders about the extent to which redesign costs might be incurred, including due to energy assessments being made late in the building approvals process, meaning that non-compliance with heating or cooling load limits might not be discovered until after design drawings are complete (but prior to construction commencement).

As noted in Chapter 6, stakeholder responses on this question were highly diverse. 11 indicated it was reasonable to assume that ratings are done early; 10 indicated it was not reasonable; 7 provided no response; and 5 indicated the answer varies by segment/location or other factors. There appears to be a consensus, however, that late-stage energy assessments do occur in some cases, with many offering the view that this practice is most prevalent with smaller builders. Many felt that this is a poor practice that can lead to unnecessarily high costs for construction and/or home owners, and some hoped the current regulatory proposal may help to change this practice.

For the Decision RIS, we allow for one-off redesign costs to be incurred over the whole 10 years for the regulatory option (and none for the non-regulatory option, as any such costs would be voluntarily incurred). We allowed for up to 20% of this cohort to incur one-off redesign costs at some point over the ten year period (by which time, standard designs should have been adjusted), with an allowance of 2 hrs at $150/hr for incremental energy assessment/redesign costs per (relevant) design. As these are one-off time costs associated with modifying existing designs, the stock of existing designs that remain unmodified will diminish over time. Noting that project home builders adapt and re-utilise designs many times, it is likely that the share of unmodified designs will diminish rapidly in total. However, smaller volume builders may still need to modify older designs even some years after the measure takes effect. We assume a linear (rather than exponential, as may be expected) reduction in the stock of unmodified existing designs, such that no unmodified designs remain after 10 years.

In the Consultation RIS, we made an allowance for the likelihood that one-off redesign costs may be incurred by some builders. The cost is the time that may be required to change a pre-existing design to ensure that limits are met. Note that brand new designs, drawn after the implementation of this measure, would be assumed (and required, if implemented by regulation) to comply, as indeed they must with all other then-existing building regulations, and so no incremental cost arises for these new designs. However, we estimate that only 70% of dwellings seek compliance via the NatHERS pathway and that all of NSW, Tasmania and much of Northern Australia is excluded. Second, the regulatory proposal aims to influence only 10% of the remaining designs; that is, 7% of annual completions in the relevant climate zones. TIC (2018) identifies that in the vast majority of cases where changes are required, minor specification changes, rather than design changes, would be sufficient to ensure that load limits are met.

The allowance for redesign costs totals some $327,000 in FY2020 for Class 1s but falls to around $37,000 in FY2029, reflecting the reduction in unmodified existing designs over time. For Class 2 dwellings, the equivalent costs are $104,000 in FY2020 and $12,400 in FY2029. This is based on a conservative estimate that up to 20% of impacted designs may require some additional time to identify design changes to comply with a heating or cooling load limit. As noted, many of the changes required are minor specification changes only, with no additional design or assessment time required.

Under the non-regulatory option, redesign costs would not arise as there is no mandatory driver for compliance and designs are adjusted voluntarily.

Search and Checking Time Costs

As discussed above, the implementation of heating and cooling load limits would require that energy assessors look up the ABCB Standard online, to ensure that their designs comply with limits are required, including as a function of the climate zone in which the design is located. Similarly, as the Universal Certificate states the heating and cooling loads for a given design, but will not indicate whether or not these loads comply with Code requirements, building surveyors will need to check online in a similar manner to assessors. In theory, these steps will be required for all designs that seek compliance using the NatHERS pathway, although in reality, it would be reasonable to expect that both assessors and surveyors would learn at least to exclude from this process designs in exempt climate regions. Similarly, assessors and surveyors working in relevant climate zones are very likely to download the Standard and keep relevant tables handy, meaning that the time commitment to check applicable limits may be very limited. Nevertheless, an allowance for 5 minutes time cost for each energy assessor and building surveyor, at $150/hr, to look up and verify the load limits for all designs expected to seek compliance under the NatHERS pathway is assumed as the average time taken to verify compliance with the proposed load limits. Due to the large number of designs for which this time commitment is required, the estimated costs are significant, rising from $4.2 million in FY2020 to $4.9 million in FY2029, due to the assumed growth in new dwellings over time.

4.1.8 Discount Rates

In line with Office of Best Practice Regulation guidance, a default real discount rate of 7% is used, with 3% and 10% tested in sensitivity analysis.

A number of stakeholders questioned the use of a 7% real discount rate and suggested the use of a lower value. We note that, in this case, the discount rate has no material impact on the analysis – as indicated in the sensitivity analysis sections.

4.2 Impacts of Option 1 – Status Quo

In regulation impact statements, the net benefit or cost associated with the status quo is generally defined as zero. However, from the perspective of economics, it can also be considered that there is an *opportunity cost* associated with failing to make a choice that would have improved economic welfare. This cost can be thought of as the value foregone by failing to select the option that would have delivered the greatest benefit for society as a whole. If the feasible options, other than the status quo, have a *negative* net present value, then the status quo represents the option with the highest net benefit for society, and the opportunity cost incurred by remaining with the status quo is zero. However, if there are feasible options that have a *positive* net present value, then retaining the status quo involves incurring an opportunity cost, the size of which is given by the net present value (NPV) of the feasible alternative that has the highest NPV. In this case, Option 2 has an NPV of $71.7 million, and this potential benefit would be foregone under Option 1.

4.3 Impacts of Option 2 - Regulation

The results are presented by building class as well as state/territory. For the reference case, we select:

- an average of the savings estimated for concrete slab and timber floors
- the 'central policy scenario' for shadow carbon prices
- the least cost solutions
- a 7% real discount rate.

Other scenarios are then explored in sensitivity analyses.

4.3.1 Summary Results – Class 1 – Reference Case

The overall results for Class 1 dwellings, using the assumptions and methodology above, indicate that energy and external benefits valued at $16.9 million would be generated, as the primary impact, while, in addition, overall construction costs would fall by some $17.5 million nationally. Adding these, the NPV of the measure is expected to reach $34.4 million for this dwelling Class. Since construction costs fall, on average, benefit cost ratios are negative overall. See Table 5 below.

Table 5: Summary Results: Option 2: Class 1 Dwellings

Jurisdiction	Units	Present Value of Benefits	Present Value of Costs	Net Present Values	Benefit Cost Ratios
VIC	$'000	$7,348	$5,601	$1,747	1.31
QLD	$'000	$2,631	-$7,292	$9,923	*negative*
SA	$'000	$1,684	$212	$1,472	7.95
WA	$'000	$4,691	-$16,231	$20,922	*negative*

Jurisdiction	Units	Present Value of Benefits	Present Value of Costs	Net Present Values	Benefit Cost Ratios
ACT	$'000	$531	$224	$307	2.37
Total	$'000	**$16,885**	**-$17,487**	**$34,372**	*negative*

Since the Consultation RIS, some dwelling archetypes in some climate zones have been recosted, following advice from TIC that certain strategies – notably, 'use of manufacturers' windows rather than default windows', and changing window frame colour, should be treated as zero cost options. The former strategy relates to a choice made by the energy assessor in how windows are modelled, rather than assuming any change in the actual windows or their costs. TIC noted that, in the past, many window suppliers had not provided NatHERS data files. This has now been largely addressed, and particularly by the major manufacturers, so there is less call for assessors to select default windows when rating a design. Second, TIC noted that the modelling assumed the standard colour palette available from volume frame suppliers. As a result, any of the frame colours noted can be selected without additional cost. In addition, TIC identified additional low or zero cost options for some designs. This is consistent with the observation in Section 4.1.7 that a wide range of solutions would be open to designers, including many options with low, no or negative construction cost implications.

The above benefit cost results reflect the following key modelling outcomes:

- National energy savings of some 1,100 GJ in FY2019/2020, accumulating to 11,380 GJ by FY2028/2029 and remaining constant thereafter (for the economic lives of the cohort of buildings affected by the measure).
- The value of the above savings rises to $1.1 million in FY2028/2029; these continue to grow slowly to 2037, given our assumption of rising electricity prices over this period.
- Shadow carbon prices contribute relatively little to the net social benefit in this scenario (central policy), totalling $110,000 by FY2028/2029; these continue to rise slowly over time, given our assumption of rising shadow carbon prices.
- The value of avoided electricity network infrastructure costs rises to $475,000 by FY2028/2029, and remaining constant thereafter. These savings persist over time because the energy savings are sustained, enabling the associated network costs to be deferred over the 40-year life of the dwellings. These savings estimates are generated directly from the energy savings note above, using the methodology described in Section 4.1.6 above.
- Total costs are negative in each year, as construction cost savings are modelled to more than offset the training and other costs described, resulting in an average annual net cost saving of $1.7 million in 2020 rising to $3.2 million in 2029. This reflects rising Class 1 construction activity over time.

- 75% of the information/education costs noted above are allocated to Class 1 dwellings, in broad proportion to the Class 1/Class 2 stock split.

The high overall cost effectiveness of this scenario is driven in roughly equal measure by the energy cost reductions and other benefits, on the one hand, and by the reduction in construction costs that are modelled to occur in most jurisdictions, on the other. As is discussed in Section 4.3.2 below, the construction cost reduction depends on designers and builders making least cost choices, as is conventionally assumed. In practice, education and training is expected to support such least cost options being identified and selected.

Regulatory Burden

The regulatory burden for for Class 1 buildings would average *minus* $2.8 million per year over the 10 year period – see Table 6. This represents the net effect of reduced construction costs, on average, offset by time-related costs for training over three years, checking limit tables, and one-off redesign work..

Table 6: Average Annual Regulatory Burden by Sector: Class 1 Dwellings: $'000

Change in costs	Business	Community organisations	Individuals	Total change in costs
Total, by sector	-$2,762	$0	$0	-$2,762

4.3.2 Sensitivity Analyses – Class 1

Noting the negative cost outcomes for the reference case, sensitivity analyses on variables that contribute to the benefits have little impact on the overall results. Nevertheless, we note the following results:

- A 3% discount rate lifts the NPV to $55.4 million, while a 10% discount rate reduces it to $26.2 million
- If all (Class 1 dwellings) were built with concrete slab on ground construction techniques, estimated energy savings would be slightly higher, leading to an NPV of $35.4 million; if all dwellings were built with timber floors, the NPV would be $33.4 million, about $1 million less than the reference case
- Selecting the 'high' shadow carbon price lifts the NPV to $36.0 million, while the 'low' scenario is very similar to the central policy scenario used in the reference case (NPV = $34.3 million)

- Adding 50% to the assumed information and education costs (that is, a total of $1.05 million for each of 3 years) makes a negligible difference to the reference NPV, reducing it to $33.6 million.

Of these, only the discount rate generates a material difference. This occurs because the additional compliance costs are incurred in the first 10 years, while the benefits are spread out (and generally rising in value) over at least 40 years (indeed, for 40 years after the final dwelling is built to the revised requirement). The effect of a higher discount rate is to increase the weighting of costs and benefits that occur in the short term, and these are dominated by costs, hence the NPV falls. Conversely, the effect of a lower discount rate is to weight costs more evenly over time, meaning that the rising benefits that occur over the latter years have greater prominence, leading to a higher NPV.

However, the key point is that the measure remains highly cost effective regardless of all these sensitivity analyses. Even if we 'stress test' the model by assuming the worst of all assumptions – setting aside costs for the moment – we still see a significant NPV of $24.7 million. This result is generated with timber floors, the low shadow carbon price, a 10% real discount rate, and 50% higher than reference information/education costs – but retaining the assumption of least compliance costs.

Turning to the compliance costs, and as discussed further in Section 4.3 below, we find that that if designers and builders were to systematically chose the highest cost solution – a highly unlikely scenario – then the regulatory change would no longer be cost effective. The NPV would be *minus* $107 million. If we instead assume that designers and builders use a mix of strategies to achieve compliance, represented by the simple average of the costs calculated for all the compliance pathways identified by TIC (noting that other compliance pathways could be identified), then still the present value of costs incurred would outweigh the present value of benefits. This result occurs because, as described in more detail in Appendix A, the range of strategies available to achieve compliance – for any given design and climate zone – is very broad, and some would involve significant costs. Examples would include adding significant insulation or increasing glazing performance specifications.

Conventionally, we assume that market actors are rational and will make least-cost choices, at least most of the time and on average. On this basis, we could dismiss these sensitivity analysis results. However, we note that there is a risk that some market actors – particularly including house owners – may lack the understanding of the significance of what, on face value, can appear to be trivial or aesthetic choices – such roof, brick or window frame colour. On these grounds, there is a risk that consumers could make choices that are sub-optimal from an energy efficiency perspective, forcing higher-cost solutions to be adopted to achieve compliance.

Conventionally, again, we should assume that builders or designers would inform their clients of the cost consequences of their choices, leading to an increase in least-cost decisions, but it is at least conceivable that this might not always happen. If the consumer were not aware of the cost consequences – which, as noted, could occur if the designer or builder fails to fully appreciate the consequences and then pass the information on to the consumer– then a less efficient solution could be selected. Overall it is likely that some people will choose higher cost solutions under the regulatory option (e.g. on aesthetic grounds or for other reasons). This may lead them to adjust other parts of the design or structure to meet the heating or cooling load limits relevant to the Class of building and climate zone. While the number of people choosing the higher cost solution is expected to be minimal, there is still a risk that they will face higher costs under the preferred option.

The Consultation RIS asked stakeholders to consider whether the least cost options identified were viewed as viable solutions, and whether practitioners are likely to adopt these solutions in the majority of circumstances. The majority of submissions indicate that the least cost options are viable. 15 indicated 'yes' or 'generally', with qualifications noted below. 12 provided no response (one indicated 'not able to verify'). 3 indicated 'no', and 3 more expressed concerns about least cost solutions being implemented. Concerns included:

- Some solutions named (in the TIC Report) – like improved house orientation – are best dealt with through planning schemes
- The practicality or acceptability to clients of changing glazed areas, floor treatments or roof/frame/window colours, and particularly for 'high end' projects – due to aesthetic preferences of clients or builders
- Many submissions noted the need for education and awareness-raising in this context
- Many qualified their 'yes' response with provisos such as "as long as it doesn't interfere with a style or marketing position that a company has"
- Some submissions noted that early assessments will increase the likelihood of least cost options
- One submission noted that least-cost outcomes for builders may not be least cost outcomes for home owners.

Overall, it appears most stakeholders agree that least-cost choices are viable and that they will be made in the majority of cases, particularly by high-volume builders. The point that education and awareness raising would assist industry to recognise and implement least cost solutions is acknowledged and reflected in this RIS.

To test the measure's tolerance of sub-optimal energy efficiency choices being made, we conducted further sensitivity analyses where the percentage of situations where highest cost choices are made is a variable. We found that, for Class 1 buildings on reference settings (other than compliance cost), provided less than 25% of new floor area is built using highest cost solutions, then the measure is cost effective. That is, it would require at least 25% of designers/builders to make sub-optimal choices or conscious aesthetic decisions, imposing the highest costs rather than minimum necessary costs on their clients, before the measure would not be cost effective. Note that this value (25%) is smaller than that in the Consultation RIS due to assumption of higher compliance costs associated with looking up values in the ABCB Standard.

4.3.3 Summary Results – Class 2 – Reference Case

As with Class 1 dwellings, we report here BCA findings based on:

- the 'central policy scenario' for shadow carbon prices
- the least cost solutions
- a 7% real discount rate.

Other scenarios are then explored in sensitivity analyses. Note that there is no choice of floor types for Class 2 dwellings, and these are almost invariably built with concrete floors.

The overall pattern of results for Class 2 dwellings mirrors that for Class 1 dwellings. Overall, we find that on the reference case, the mooted regulatory change is highly cost effective, again generating negative benefit cost ratios (for all jurisdictions, with the apparent exception of QLD – see below), along with a substantial NPV of $37.3 million – see Table 7 below. This includes the primary, or intended, energy savings benefit of some $3.7 million, together with an estimated construction cost saving, on average, totalling $33.6 million.

Table 7: Summary Results: Regulatory Option Reference Case: Class 2 Dwellings

Jurisdiction	Units	Present Value of Benefits	Present Value of Costs	Net Present Values	Benefit Cost Ratios
VIC	$'000	$2,826	-$30,174	$33,000	*negative*
QLD	$'000	$254	$1,249	-$995	0.20
SA	$'000	$117	-$1,295	$1,412	*negative*
WA	$'000	$459	-$1,707	$2,166	*negative*
ACT	$'000	$53	-$1,675	$1,728	*negative*
Total	$'000	**$3,709**	**-$33,603**	**$37,312**	*negative*

These results appear to suggest that the measure would not be cost-effective in QLD. However, it should be noted that the analysis of impacts is based on a limited sample of designs and climate zones, and the results are therefore sensitive to the particular design attributes of the archetypes selected by TIC for analysis. The design that modestly failed (5 star) heating load limits in Brisbane could have achieved the load limit at negative cost by replacing tinted with clear windows, or reducing window area (although in practice, when this actual apartment was designed, both were rejected on aesthetic grounds, requiring recourse to higher cost solutions such as low-e coated windows or higher wall/ceiling insulation specifications). While the change in construction cost for this apartment could therefore have been negative, the modelled energy cost savings are also modest and more than offset by the modelled regulatory burden and (Qld's share of) government costs, leading to a negative result overall. It should not be assumed that this result is typical of all new apartments in Queensland, or that the measure overall would generate net negative benefits in Queensland. Rather, this result is thought to reflect the challenges of this particular design.

The same apartment, when modelled on a western façade, failed to reach a 5 star average and also failed the cooling load limit, due to '90% of its glazing facing in the one direction [west]'. As noted earlier, TIC were able to identify additional low- or zero-cost options to address this particular design, including:

- Change window frame colour from dark to light. This allows the wall insulation to be reduced from polystyrene board to foil on inside of plasterboard.
- Increase size of ceiling fan in the living area from 900 mm to 1400 mm and add a 1200 mm fan to bedroom 1. This also allows the wall insulation to be reduced from polystyrene board to foil on inside of plasterboard.
- Replace timber floor covering to living area with ceramic tiles and use a medium coloured external wall instead of dark. This allows the wall insulation to be reduced from polystyrene board to foil on inside of plasterboard.

Generally, this example illustrates the importance of making climate-adapted design choices, such as avoiding excessive glazing on (un- or poorly-shaded) western facades, to achieve comfortable living conditions at the least cost possible. Where poorly-adapted design choices are made, higher costs are likely to be incurred to achieve the same comfort outcome. This in turn underscores the importance of informing and educating building professionals regarding this aspect of housing design.

Overall, then, we conclude that the apparent non-cost-effectiveness of this measure in QLD is a modelling artefact and not an inherent property of QLD designs or markets.

The key parameters generating results noted above are as follows. Note that the methodology used to estimating these savings is described in Section 4.1, and again in Section 4.3.1 above.

- Annual energy savings of 2,600 GJ by FY2028/2029, and sustained at that level for the balance of the analysis period
- The value of energy savings is $247,000 by FY2028/2029, and continuing to rise slowly over time, due to an expectation of rising electricity prices
- As with Class 1 dwellings, shadow carbon prices make a small contribution to the net social benefit, of $28,500 in FY2028/2029, and rising slowly thereafter due to an assumption of higher shadow carbon prices over time
- The value of avoided network augmentation costs is just over $100,000 by FY2028/2029, and remaining at that level for the balance of the period
- Incremental construction costs are again negative, amounting to a net *saving* of $5.6 million in FY2019/2020 rising to $6.7 million by FY2028/2029 due to assumed stock growth rates over time
- 25% of the information and education costs are allocated to Class 2 dwellings.

Regulatory Burden

For Class 2 dwellings, regulatory costs to industry would average *minus* $4.9 million per year over the 10 year period, as shown in Table 8 below. As with Class 1 dwellings, this represents the net impact of reduced construction costs, on average, offset to some degree by time-related costs associated with training, checking limit tables and one-off redesign work.

Table 8: Regulatory Burden and Cost Distribution – Class 2 dwellings – $'000

Change in costs	Business	Community organisations	Individuals	Total change in costs
Total, by sector	-$4,922	$0	$0	-$4,922

4.3.4 Sensitivity Analyses – Class 2

To a greater degree than for Class 1 dwellings, the estimated construction cost savings mean that most sensitivity analyses, except for incremental compliance costs, are immaterial. Nevertheless, we note that:

- Selecting a 3% real discount rate increases the NPV of the measure to $48.6 million, while a 10% real discount rate reduces the reference NPV to $31.6 million
- The high shadow carbon price scenario lifts the NPV to $37.7 million, while the low shadow carbon price reduces the NPV to just under $37.3 million
- Increasing information and education costs by 50% reduces the NPV of the measure to $37.1 million.

As with the Class 1 dwellings, the Class 2 dwellings remain highly cost effective throughout these sensitivity analyses. Stress testing by selecting all of the least favourable values above simultaneously still results in an NPV of $31.4 million.

Further, our sensitivity analysis with respect to compliance costs reveals the same pattern as for Class 1 dwellings: if all designers and builders choose highest cost solutions, the measure would not be cost effective, with an NPV of *minus* $65.7 million and a BCR of 0.05. The break even threshold for cost-effectiveness of the measure occurs where the mix of solutions chosen include not more than 36% of the highest cost solutions. This value is higher than for Class 1s, as the results indicate higher cost effectiveness for Class 2 dwellings on average, equating a higher threshold for highest cost solutions. As with Class 1s, there is no reason to assume that designers will choose high cost solutions when lower or negative cost solutions are available and align with their client's preferences. As before, we note that providing information and education, designed to encourage most designers and builders to recognise and utilise least cost solutions, would be essential.

4.3.5 Combined Results – Class 1 and 2

Table 9 below combines the key benefit cost analysis results for Class 1 and Class 2 dwellings, in the reference case. It shows that the regulatory option as described, including an information and education program, is highly cost-effective, with a combined benefit of over $71 million in net present value terms.

Table 9: Summary of Benefit Cost Analysis – Class 1 and Class 2 Dwellings, Regulatory Option, Reference Case

	Present Value of Benefits ($'000)	Present Value of Costs ($'000)	Net Present Values ($'000)	Benefit Cost Ratios
VIC	$10,174	-$24,573	$34,748	*negative*
QLD	$2,885	-$6,044	$8,928	*negative*
SA	$1,801	-$1,083	$2,884	*negative*
WA	$5,150	-$17,938	$23,089	*negative*
ACT	$583	-$1,451	$2,035	*negative*
Total	**$20,594**	**-$51,090**	**$71,684**	*negative*

4.4 Impacts of Option 3: Voluntary Implementation

4.4.1 Introduction

As discussed in Chapter 3, the most plausible non-regulatory option to address the identified problem would be through the provision of targeted information and education programs. Such programs could draw on the work completed by TIC, along with other relevant materials, to highlight the underlying causes of excessive heating or cooling loads, as a joint function of details of design and specification, on the one hand, and climate zone, on the other hand. The programs would also highlight the range of possible solutions, and the consequences for incremental building costs, inter alia, of those choices.

Options for this program would include:

- Preparation of an ABCB Training PowerPoint, published via the ABCB website
- Incorporation of a training module on these issues in Certificate IV energy assessor training under the NatHERS scheme
- Inclusion of information in a new edition of *Your Home*, which we understand is to be updated shortly by the Department of the Environment and Energy

- Inclusion of a module on these issues in state-based Continuous Professional Development (CPD) training schemes.

Other practices, such as the timing and purpose of energy simulation modelling or ratings, within the overall design and construction process, would be relevant to bring within the information and training package. For example, if thermal modelling or rating is done only after designs and specifications are complete, designers are unlikely to alter their designs voluntarily. On the other hand, if designs are rated earlier in the overall process, and with the explicit intention of optimising the design for the climate and from a cost perspective, then the chances of achieving both compliant and least-cost designs will be greatly enhanced.

4.4.2 Modelling Issues and Methodology

The primary challenge in modelling the impact of any information and education-based strategy is that there is uncertainty about the effectiveness of this approach in ultimately achieving a similar outcome to the regulatory solution. A secondary uncertainty is what costs would need to be incurred to develop and deliver an effective information/education based strategy and, combining these two, what incremental impact is likely be delivered as the information/education budget is varied.

A review of literature provided many more advisory or guidance notes on how to undertake evaluations than published evaluations. It would appear that program evaluations of purely information or education based programs are undertaken relatively infrequently. Key sectors where such evaluations are to be found include health programs, social behaviour change programs, and voluntary travel behaviour change. Whether these would provide useful analogies for expected uptake of quite specific information, to deliver a very specific outcome in building design and performance, is moot.

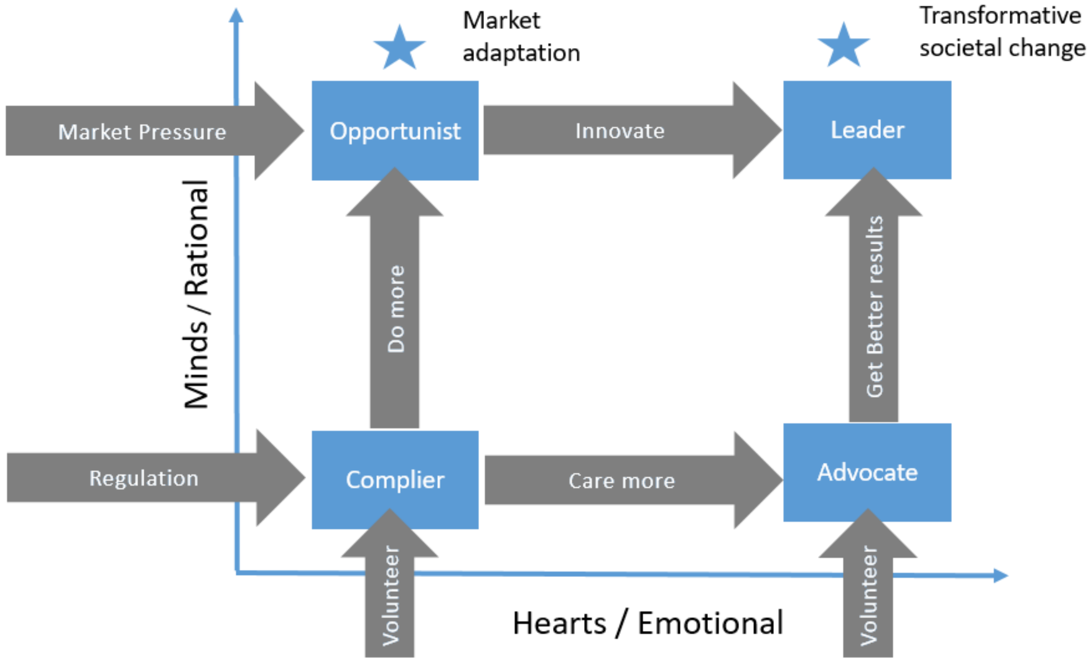
There are voluntary behaviour-based programs in Australia in the area of building energy efficiency. The CitySwitch program, for example, is a voluntary information-based program that focuses on commercial office tenants, and aims to:

- *educate and inspire with a respected event series and through the provision of toolkits, workbooks, case studies and site tours.*
- *facilitate links to other programs, information sources, industry bodies and communities of interest by identifying the market expertise that Signatories might need in order to build corporate capacity, systems and comply with evolving legislative requirements.*
- *signpost to incentives and financial vehicles that are available to expedite the uptake of energy efficiency investments.*

- *celebrate and reward environmental leadership and achievement though its annual awards and ongoing member promotions in order to create competitive advantage for its signatories wherever possible.*[35]

CitySwitch program managers have different 'theories of action' or change that they regularly test, via an extensive survey of program participants, and by careful quantitative analysis of the results – see Figure 9 below.[36] This particular framework recognises that there are a range of potential motivators for action – such as degrees of market or regulatory pressure – and also a range of possible responses that may reflect an individual's or a company's perception of itself, for example as a market leader, or as an opportunist, compiler of evidence, or others.

Figure 9: CitySwitch Program Theories of Action



Source: CitySwitch National Administration

From these and other evaluations, we can say that it is difficult to predict, a priori, the response of a particular set of stakeholders to a particular information/education strategy. Designing an effective information/education based strategy would require not only sound knowledge of the problems and solutions, from a technical perspective, but also in-depth knowledge of, or research into, the motivations, barriers and opportunities as perceived by the market participants themselves. In all probability, a range of different strategies would be used to target the full range of intended audiences.

[35] What is City Switch?, viewed 1/11/2017.
[36] This work is currently undertaken annually by *Strategy. Policy. Research.*

In the *National Energy Efficient Buildings Project*, for example, Swinburne University of Technology undertook focused research on the 'knowledge management' dimensions of the wider issue of compliance with the energy performance requirements of the NCC.[37] Swinburne found, inter alia:[38]

- The diversity of (i) climatic zones across Australia, (ii) patterns of regulations and training provision across states/territories, and (iii) the information and skill need of different roles/stakeholders in the construction cycle require the development and provision of specific rather than generic information, guidelines and training programs.
- Pre-employment training in energy efficiency is uneven and there is a perception that many instructors are in need of significant professional development in this area.
- Mismatches between what is delivered in training and the 'wash-out' that occurs when other on-site priorities (especially cost factors and the need to attend more closely to aspects of construction that are most often reviewed by building assessors) undermine the actual application of energy efficiency skills.
- This may reflect problems with the building assessment sector of the construction industry which do not mandate energy efficient testing (e.g. through thermal imaging or air pressure tests) and the related course curricula which do not require Cert IV building assessors to show competence in use of rating tools or energy efficiency testing.
- Many excellent training opportunities provided by industry and trade associations are not widely accessed by members as few associations mandate energy efficiency certification.
- Extreme disparities between levels of knowledge and skills for energy efficiency across job roles, which cause on-site communication problems.
- Inaccurate and/or ineffective peer-to-peer explanations and demonstrations of energy efficiency concepts and skills.
- Inappropriate specification or substitution of fit-for-purpose materials and incorrect or incomplete installation.

Generally, this literature appears to support a cautious assessment of the expected uptake of information/education programs in the Australian building industry. In the absence of specific and relevant precedent, we believe it would be reasonable to make assumptions such as:

- Of those who participate in training and awareness programs, or are exposed to the information resources, only a modest percentage – perhaps 25% – would be likely to act immediately and consistently on this information, although this rate could be increased with repetition and reinforcement of key messages and lessons.[39] It should be noted that potential construction cost savings accrue to the future home owner and not to the designer

[37] pitt&sherry and Swinburne University of Technology, *National Energy Efficient Buildings Project – Phase 1 Report*, December 2014.
[38] Ibid, p. xx.
[39] Hence the suggestion that the program runs for 3 years, not 1.

or energy assessor, and this limits the financial incentive to act on this information voluntarily. The use of multiple communication channels, and innovative program design and delivery strategies (phone apps, etc), could enhance take-up and implementation rates.

- While, as noted, there is a shortage of hard evidence about the effectiveness of voluntary training and awareness-raising programs, we assume modest take-up in the first year bur rising over time, including due to reinforcement of messages in annual CPD training or other information channels.

We therefore make the assumption, for the reference case, that take-up increases by 5 percentage points for each of the three years of the information program, but then continues to rise more slowly (by 2.5 percentage points per year) over the balance of the period to FY2028/2029 – see Table 10 below. This reflects an expectation that, over time, new industry knowledge would spread by word-of-mouth, changed work practices and embedding of new learning in ongoing education and information programs, even without ongoing financial support from governments.

Table 10: Reference Case Take-up Rate Assumptions – Non-Regulatory Option

FY	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Take-up rate	5.0%	10.0%	15.0%	17.5%	20.0%	22.5%	25.0%	27.5%	30.0%	32.5%

Importantly, the degree of uptake of the non-regulatory solution will determine the extent of both costs and benefits, and these in a proportional manner. For example, if there were no uptake at all, then there would be no benefits (such as energy and externality savings), but there would also be no (incremental) compliance costs. Costs would, of course, be incurred in developing and delivering the information and education program. If there were 50% uptake of the key messages, then we could expect that 50% of the identified opportunity would be acted upon, realising 50% of the compliance costs and 50% of the social benefits. We test different take-up rates in sensitivity analysis.

Master Builders Australia queried why there is expected to be low take-up of the measure on a voluntary basis. As detailed in Chapter 6, many submissions argued points such as:

- This issue is likely to be treated as a low priority in the absence of regulation
- Where solutions conflicted with consumers' aesthetic preferences, they are not likely to be implemented
- The issue may be hard to explain to consumers, and could appear counter-initative or too trivial to warrant attention
- Professionals would have little motivation to undertake awareness and training on this question in the absence of a regulatory driver for implementation – beyond the CPD training that they may be doing in any case.

4.4.3 Summary Results – Class 1

Table 11 below summarises the key results on 'reference' assumptions. As before, these include:

- an average of the savings estimated for concrete slab and timber floors
- the 'central policy scenario' for shadow carbon prices
- the least cost solutions
- a 7% real discount rate.

Table 11: Summary Benefit Cost Analysis Results – Class 1 – Non-Regulatory Option, Reference Case

Jurisdiction	Units	Present Values of Benefits	Present Values of Costs	Net Present Values	Benefit Cost Ratios
VIC	$'000	$1,400	-$693	$2,094	2.81
QLD	$'000	$500	-$2,403	$2,903	*negative*
SA	$'000	$320	-$184	$504	4.94
WA	$'000	$893	-$3,999	$4,892	*negative*
ACT	$'000	$101	$73	$28	1.39
Total	$'000	**$3,214**	**-$7,206**	**$10,421**	*negative*

These outcomes derive from the following key observations:

- This option would generate energy savings of 2,400 GJ by FY2028/2029, and remaining at this level thereafter
- By FY2028/2029, these energy saving would be valued at $232,000, and rising slowly thereafter in real terms
- The value of avoided carbon emissions would reach around $30,000 by FY2028/2029 and grow slowly from that point
- Network infrastructure cost savings are also modest, in line with energy savings, valued at around $98,000 in FY2028/2029
- Incremental construction costs are again negative overall, with a construction cost saving in FY2019/2020 of $301,000, rising to $2.2 million by FY2028/2029 (due to the assumed ramp up in implementation over time); diminished only by government costs associated with the awareness and education program – see Table 13 below.
- We assume the same program of information and education as in the regulatory option, with the Class 1 share of the program costs totalling $560,000 in each of FY2020 – 2022.

On these assumptions, the measure is highly cost effective, due primarily to lower construction costs on average. Due to the voluntary nature of this option, we delete costs associated with building surveyors checking load limits, as there would be no requirement to do so. Look-up time costs are retained, but factored down to the assumed take-up rates noted.

However, given the lower expected take up and implementation of actions to limit high heating and cooling load limits, both benefits and costs are significantly lower than in the regulatory case, with the NPV of the measure being some $10.4 million, compared to $34.4 million for the regulatory option (Class 1 dwellings only).

4.4.4 Sensitivity Analyses

Noting the negative construction costs associated with the non-regulatory option, we can conclude that, as with the regulatory option, this measure will be very insensitive to reasonable variations in key assumptions. For example, even if we doubled the cost of the information and education program, to $1.4 million per year in total (for Class 1 and 2 dwellings), the NPV would fall modestly to around $9.0 million. Importantly, this calculation does not take into account the likelihood that greater information and education effort would see higher take up of the measure, and therefore higher, rather than lower, net benefits.

We do not test the sensitivity of this voluntary measure to higher cost compliance choices, as high-cost solutions are unlikely to be implemented when compliance with the measure is voluntary: take-up on a voluntary basis is only likely where no additional costs were involved or, moreso, if construction cost *savings* can realised at the same time.. As discussed above, the concerns that lead to an assumption of modest uptake of the measure on a voluntary basis include:

- The required changes are not obvious or intuitive, but require some considered thought (or modelling) to achieve least-cost and compliant outcomes
- The required changes may be difficult to communicate to house buyers, and least-cost solutions may in some cases compete with aesthetic preferences
- Concerns expressed by Swinburne University of Technology about the likely effectiveness of information and education based strategies in the building industry.[40]

For these reasons, it is reasonable to expect significantly lower uptake and effectiveness on a voluntary basis. This would lead to:

- Foregone energy savings for consumers
- Higher greenhouse gas emissions
- Higher electricity network infrastructure costs.

[40] These concerns would also apply to an information and education program managed in association with a regulatory change. However, in the regulatory case, the primary driver of uptake is the regulation itself, whereas in the voluntary case, the education/information program is the *only* driver of uptake.

A final sensitivity analysis conducted was to halve and then double the reference expected take-up rate. Halving the rate reduces the NPV to $4.5 million – somewhat less than half of the reference case (due to the higher proportionate weighting of the fixed costs). Doubling the take-up rate (to 10% in year 1, and 65% in year 10) slightly more than doubles the reference NPV, to $22.3 million.

4.4.5 Summary Results – Class 2

The results of the benefit cost analysis for Class 2 dwellings reproduce the same pattern as for Class 1 dwellings, and therefore the data is presented in summary form. An overview is provided in Table 12.

Table 12: Summary Results: Benefit Cost Analysis: Class 2 Dwellings: Non-Regulatory Option: Reference Scenario

Jurisdiction	Units	Present Value of Benefits	Present Value of Costs	Net Present Value	Benefit Cost Ratios
VIC	$'000	$542	-$6,513	$7,055	*negative*
QLD	$'000	$61	-$113	$174	*negative*
SA	$'000	$22	-$349	$371	*negative*
WA	$'000	$88	-$653	$741	*negative*
ACT	$'000	$10	-$332	$342	*negative*
Total	$'000	**$724**	**-$7,960**	**$8,684**	*negative*

The reduction in future construction costs dominate the analysis, although other benefits are expected to generate a present value of $724,000. Overall, the NPV of $8.7 million is significant, but more than 4 times lower than the regulatory option for Class 2 dwellings.

4.4.6 Sensitivity Analyses – Class 2 Dwellings

As with previous scenarios, the only significant variable for the benefit cost analysis is the incremental cost of construction, but high cost solutions are unlikely to be selected if the measure is implemented on a voluntary basis.

4.4.7 DTS Elemental Solutions

For dwellings that demonstrate Code compliance using the 'deemed to satisfy' (DTS) elemental provisions no heating or cooling load limits will apply. The ABCB understands, based on internal modelling work, that dwellings (including additions and alterations) complying with DTS elemental provisions are not expected to exhibit unbalanced heating and cooling loads, making separate load limits redundant. As discussed in Chapter 2, unbalanced loads can, however, arise under NatHERS due to the annual average nature of the thermal load performance requirement, which allows for a very wide range of compliant solutions, including some that may have poorly balanced heating and cooling load performance.

On the question of compliance, the existing Universal Certificates issued under the NatHERS scheme already clearly identify the modelled heating and cooling loads of designs.

4.4.8 Compliance

Compliance with the heating and cooling limits under Option 2 (regulation) would be expected to occur in the same manner as currently occurs for the estimated 70% of new dwellings that opt to demonstrate compliance with the Code's energy performance requirements via the NatHERS pathway. That is, designs would be submitted to an energy assessor who models the design in an accredited software package (AccuRate, FirstRate5 or BERS Pro). These packages all produce the same Universal Certificate which includes a record of not only the star rating achieved, but also the heating and cooling loads modelled. This certificate is able to be inspected by a building surveyor and, once satisfied, the building surveyor 'signs off' that the design complies with all relevant Code requirements. The fact that the Universal Certificate indicates heating and cooling loads would facilitate compliance-checking and enforcement activities, as well as enabling data capture (by agreement with CSIRO, the data owner) for regulatory review and evaluation purposes in future.

Overall, this proposal is not expected to impact on Code compliance rates, either positively or negatively. Also, we are not aware of any evidence that rates of compliance with Code requirements, including energy performance requirements, vary by dwelling class or market segment. The primary risk of non-compliance with the heating and cooling load limits would arise if energy assessors/designers neglected to check the proposed ABCB Standard and, in addition, the building surveyor did the same. Two process failures would thus be required for a non-compliance to occur. As a default, we assume that dwellings will comply with the limits if imposed via the Code. That said, we note that any non-compliance with the load limits would essentially continue the status quo, with neither costs nor benefits arising, but with continued opportunity costs, as is also the case under Option 1, status quo.

4.4.9 Summary – Class 1 and Class 2 Dwellings

Combining the above results for the reference case generates the following summary indicators – see Table 13 below. The combined NPV is $19.1 million, around 4 times lower than for the regulatory option.

Table 13: Summary Indicators: Benefit Cost Analysis: Class 1 and Class 2 Dwellings: Non-Regulatory Option: Reference Scenario

	Present Value of Benefits ($'000)	Present Value of Costs ($'000)	Net Present Values ($'000)	Benefit Cost Ratios
VIC	$1,942	-$7,206	$9,149	*negative*
QLD	$562	-$2,515	$3,077	*negative*

	Present Value of Benefits ($'000)	Present Value of Costs ($'000)	Net Present Values ($'000)	Benefit Cost Ratios
SA	$342	-$533	$875	*negative*
WA	$981	-$4,653	$5,633	*negative*
ACT	$111	-$259	$370	*negative*
Total	**$3,938**	**-$15,166**	**$19,105**	*negative*

4.5 Summary and Analysis

Table 14 below summarises and enables a comparison of the regulatory and non-regulatory options for all dwellings, on the reference case settings.

The benefit cost analysis clearly identifies that while both the regulatory and non-regulatory options are expected to be cost effective – indeed, highly so – the regulatory option offers the prospect of much greater take-up and therefore effectiveness in addressing the problem identified. As a result, the expected performance of the regulatory option is much higher, generating around 4 times the net social benefit (NPV) of $71.7 million. The regulatory option is expected to generate an *additional* $52.6 million of net social value when compared to the non-regulatory option. Alternatively, some $52.6 million of net social value would be foregone if a voluntary rather than a regulatory pathway were selected.

As noted, both options perform well from an economic perspective. The least cost options are agreed by the stakeholders to be feasible, and are expected to be pursued under both options, at least most of the time. However, under the regulatory option, aesthetic preferences of home owners could lead to a choice to pursue higher cost but preferred solutions. This was noted by stakeholders to be more likely at the top end of the detached housing market, but not likely for the project home market. Under the non-regulatory option, it is likely that changes to meet load limits will only be made where there are no or negative costs. Our analysis of the solutions identified by TIC – and again noting that other solutions would be possible – is that costs of the different pathways vary widely. However, for the regulatory option the measures remain cost effective provided that not more than 25% - 36% of solutions represent the highest-cost options, which is a highly unlikely prospect.

Table 14: Comparison of Key Indicators – Regulatory vs Non-Regulatory Option – All Dwellings

a. Present value of benefits ($'000)

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	$10,174	$1,942
QLD	$2,885	$562
SA	$1,801	$342
WA	$5,150	$981
ACT	$583	$111
Total	**$20,594**	**$3,938**

b. Present value of costs ($'000)

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	-$24,573	-$7,206
QLD	-$6,044	-$2,515
SA	-$1,083	-$533
WA	-$17,938	-$4,653
ACT	-$1,451	-$259
Total	**-$51,090**	**-$15,166**

c. Net present values ($'000)

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	$34,748	$9,149
QLD	$8,928	$3,077
SA	$2,884	$875
WA	$23,089	$5,633
ACT	$2,035	$370
Total	**$71,684**	**$19,105**

d. Benefit cost ratios

Jurisdiction	Regulatory Option	Non-Regulatory Option
VIC	*negative*	*negative*
QLD	*negative*	*negative*
SA	*negative*	*negative*
WA	*negative*	*negative*
ACT	*negative*	*negative*
Total	*negative*	*negative*

Notes: present values of benefits have been calculated using a 7% real discount rate over the 40 year assumed life of dwellings; while the present values of costs have been calculated using a 7% real discount rate over the assumed 10 year life of the proposed measure.

4.6 Impact on the Construction Industry

The overall impact of the proposed Options 2 and 3 on the make-up of the construction industry, is expected to be negligible.

The intent of both options is for the construction industry generally, and designers/assessors specifically, to focus on both heating and cooling loads. The designers would then be expected to be in a better position to directly and indirectly (depending on the supply chain model) explain the ramifications of design options and changes to their clients.

The quantity of design work and the delivery of design work would not change under either option to address the problem.

4.7 Impact on Competition

Similarly, neither option is expected to have a significant influence on the levels of competition. It is certain that competition would not be reduced by either option.

4.8 Business Compliance Costs

The construction cost impacts of the options are described in Appendix A.

4.9 Impact on Consumers

The principle impact of the both options is intended to improve the small percentage of designs that have the worst heating/cooling load performances in each climate zone.

As explained in the benefit cost analysis section above, it is assumed that the regulatory plus education option will eliminate 100% of the outlier designs with excessive heating or cooling loads. The education only option would eliminate a lower share of the outlier designs – with the result that some consumers will be left in under-performing homes. These consumers will miss out on the benefit of action to correct the problem. At the same time, there would be no risk of additional costs being incurred due to aesthetic or other preferences.

The cost impacts on consumers is discussed extensively in the benefit cost analysis section of this Consultation RIS.

The impact on choice is assessed as very slight under either option. Consumers will have the full range of tested solutions, and indeed others, to choose from (the TIC analysis does not purport to be a comprehensive listing of all solutions). Again, the improvement of information in the market place (more precision and better appreciation of design choice impacts) would generally be expected to favour consumers.

Well-informed consumers are better empowered to make rational choices. The extent of information improvement is expected to be stronger under the regulatory + information option.

4.10 Summary Comparison of Market Impacts of Options A and B

The expected impacts of the proposed changes are summarised in Table 15 below.

Table 15: Summary of market impacts by option

Option / Impact	Regulatory adjustment	Information campaign
Size and shape of the market	None	None
Competition	Minor, if any	Minor, if any
Consumers	Modest lifetime cost benefit and slight improvement in market power and good-choice making ability	Small lifetime cost benefit and very slight improvement in market power and good-choice making ability

5. Consultation

5.1 Process

A Consultation RIS was released by the ABCB in March 2018.[41] Submissions closed on 13 April 2018, and 32 submissions were received. 8 submissions were identical in content, and around 5 more had content that was identical to others for one or more questions.

The Consultation RIS asked the following questions:

Question 1:

The analysis assumes that building designers conduct energy efficiency assessments in the early stages of design and as a result no redesign costs are expected.

- At what stage in the building design process do you carry out energy efficiency assessments?
- Is this assumption reasonable given your experience?

Question 2:

To demonstrate clear net benefits, the ABCB needs to confirm that least cost options will be adopted in the majority of circumstances.

- Do you accept the least cost options as viable solutions in meeting the proposed changes?
- Are practitioners likely to adopt these solutions in the majority of circumstances?
- When designing a new residential building currently, do you consider the demand for both heating and cooling?

Question 3:

The analysis indicates that there are benefits associated with an effective information and education program.

- Do you find the current information available useful in describing how to meet the current energy efficiency requirements?
- Is there enough information being provided to practitioners currently?
- What type of information would be useful to practitioners? (E.g. case studies, advisory notes, handbooks, seminars etc.)

Question 4:

Of the two options considered by the analysis:

- Which is your preferred option, and why?

[41] ABCB, *NCC 2019 Consultation Regulation Impact Statement: Energy Efficiency for residential buildings: NatHERS heating and cooling load limits*, March 2018.

- Are there any other comments you would like to make in relation to the analysis?

Question 5:

For each of the years between 2020 and 2029, the analysis has estimated that on average an additional 49 million square metres of floor area will be added to the existing dwelling stock. This is comprised of 33 million square metres for Class 1 buildings and 16 million square metres for Class 2 buildings.

Do you agree with this annual estimate?

5.2 Overview of Responses

5.2.1 Question 1

Responses were highly diverse. 11 indicated it was reasonable to assume they are done early; 10 indicated it was not reasonable; 7 provided no response; 5 indicated the answer varies by segment/location or other factors.

Consensus elements appear to include:

- Most responses indicate that practices vary widely in industry and also by state and local government area
- Many note that large volume builders do master ratings for standard designs to ensure they comply, and adjust these well in advance of any regulatory changes
- Most states and territories require assessments to be completed prior to issuing building approval. This means that any non-compliances are identified prior to construction. However, if assessments are done at the last minute, after final drawings and client approvals, then redesign costs will arise if designs fail to comply
- Many submissions stated that most late-stage assessments are done by small-to-medium-sized builders
- Victorian Councils require early stage assessments and also apply cooling load requirements to Class 2 building through planning regulations
- There appears to be widespread recognition that late-stage energy assessments do occur, at least in some cases/segments. Many noted that this is a pre-existing problem that also can lead to unnecessarily high costs for construction and/or home owners. Some noted the proposed regulatory change may help to address.

5.2.2 Question 2

The majority of submissions indicate that the least cost options are viable. 15 indicated 'yes' or 'generally', with qualifications noted below. 12 provided no response (one indicated 'not able to verify'). 3 indicated 'no', and 3 more expressed concerns about least cost solutions being implemented.

On the question of whether heating and cooling is already separately considered, most submissions indicated that practices vary widely. Some 15 provided qualified support – there were no clear statements of 'yes'. Many of those answering 'yes' gave examples of poor practices they were aware, or noted that attention to this issue is limited to certain locations, or referred to evidence of poor cooling performance in particular, and/or that it is cheaper for builders to improve winter performance than summer performance. 13 provided no response. 3 indicated 'no'. Those indicating 'no' referenced NatHERS tools not making it easy to find the load limits information; load limits being poorly understood by industry and/or consumers; or 'being at the bottom of the list in terms of importance'.

Common themes included:

- Many agreed that heating and cooling 'should' be considered, but did not indicate confidence that it was being considered
- A percentage of builders will resist doing so, particularly those who treat energy assessment as a late-stage compliance process
- Some solutions named (in the TIC Report) – like improved house orientation – are best dealt with through planning schemes
- Some noted benefits from eliminating the 'worst 10% of designs', including better design practices and outcomes for consumers in future
- A number of submissions expressed concern about the practicality or acceptability to clients of changing glazed areas, floor treatments or roof/frame/window colours – due to aesthetic preferences of clients or builders. This was cited by those saying 'no'.
- One submission noted the above point will be more of a problem for high-end projects, while project home builders are more likely to adopt least-cost approaches, small to medium sized builders were more likely to rate late.
- Many suggested that clients and industry professionals alike may fail to understand the significance of these design/specification elements themselves, let alone be able to explain them to clients
- Many submissions noted the need for education and awareness-raising in this context
- Many qualified their 'yes' response with provisos such as "as long as it doesn't interfere with a style or marketing position that a company has" " and expressed concern this relied on rating early in the process.
- Some submissions noted that early assessments will increase the likelihood of least cost options

- One submission noted that least-cost outcomes for builders may not be least cost outcomes for home owners.

5.2.3 Question 3

Many submissions answered the three sub-questions jointly. 15 did not address the question directly. 12 indicated that current information is not useful, or noted specific failings. Only 1 indicated 'yes' – citing Your Home as good information, but noted many do not use it.

On the question of whether enough information is being provided, 17 provided no clear answer; 14 indicated 'no'; 2 indicated 'yes', referring to information already online.

On the question of 'what would be useful?', 14 argued that an education/awareness raising program would be essential; 10 did not respond; 2 noted that education will be more effective if there is a regulatory driver; only 1 indicated more information is unlikely to help (and preferred CPD training and assistance for professionals. Several referred to knowledge shortcomings in industry, particularly knowledge of passive design principles.

Key consensus points included:

- The majority of those responding view education, training, awareness-raising and 'upskilling' as an essential part of the response
- Several noted that compliance will be higher when good information and education is provided
- Many called for case studies to be developed, more information on NatHERS/FirstRate 5 portals, many examples of practical, compliant solutions (more than in the TIC Report); extensive technical notes
- Many called for seminars, but others noted this may not work well in the regions; including in CPD required training is more likely to see uptake; webinars useful for those in more remote areas
- Several submissions noted that information provision will not be effective unless compliance and enforcement is improved
- Many submissions stressed the need for awareness-raising and education to be widespread, including designers, architects, builders, assessors, surveyors/inspectors, trades, real estate agents
- Several submissions called for a single information portal or database, with all information needed to help practitioners to understand and comply.

5.2.4 Question 4

On the preferred implementation model, there was a clear consensus for Option 2, with 21 expressing support for the regulatory option. 2 expressed support for Option 3; 6 offered no view; and 3 indicated 'neither'.

In terms of the 'why' question, the 2 that supported Option 3 argued that it would be preferable to implement the measure voluntarily in the first instance, supported with information and seminars, and then evaluate the outcomes and consider whether a mandatory approach would be needed in FY2022. One argued that the case for making any change had not been established, describing the issue as perceived rather than actual.

2 of the 3 that answered 'neither' argued there were too many flaws in NatHERS and that these needed to be fixed first. Another felt that alternative approaches including mandatory disclosure should be used.

Key points raised by the majority supporting Option 2 included:

- The measure will only affect the 10% of 'worst' designs in each climate zone – and many saw this as a positive outcome for industry as well as consumers
- Many noted the availability of low or negative cost solutions
- Many cited the failure of voluntary approaches, specifically in the area of energy efficiency or sustainability, to achieve uptake; some flatly stated the measure would not be implemented unless made mandatory; several mentioned 'low motivation' or market failures
- Virtually all agreed that education and awareness raising will be essential – in addition to regulation – given low levels of awareness of the issue, of appropriate solutions, of the underlying building physics, and so that practitioners could explain the issue to clients in particular; even the 2 supporting Option 3 and the 3 supporting 'neither' agreed (in response to this question) that education and awareness raising would be critical
- One supporter noted their support was reluctant, due to concerns about poor compliance and enforcement
- Victorian stakeholders noted how compliance with ESD requirements was very low when implemented on a voluntary basis, and "virtually 100%" since being made a planning requirement
- One noted that uptake on a voluntary basis will lead to low uptake because there is insufficient knowledge and awareness in the industry and on the part of consumers of the relevant issues.

As might be expected with an 'other comments' question, responses were highly diverse, but common elements included:

- Many used this question to reinforce the need for information and education
- Several comments were made about BASIX – these have not been included as NSW is not impacted by this measure
- Many called for a broader and more inclusive approach to energy efficiency to be taken, citing the ASBEC Report, *The Bottom Line: household impacts of delaying improved energy requirements in the Building Code*.
- Similarly many called for a clear future trajectory for heating/cooling load limit and overall stringency increases over time, to assist with preparation and transition
- Many noted the fact that energy performance requirements have not been lifted since 2010 and called for urgent action to address this
- Many questioned the use of a 7% real discount rate and called for a lower one to be used
- Many cited poor compliance as a general risk, or specifically referred to the difficulty of ensuring compliance with load limits; one noted that compliance would be greater if ratings tools provided a simple pass/fail result, as per BASIX
- Some specifically referenced 'loopholes' both in the use of ratings software for the verification method and also in the reference building approach; and excessive 'subjectivity and discretion' by energy assessors
- The windows industry called for greater awareness of the multiple benefits of high performance glazing
- The majority of submissions expressed concern over the fact that most jurisdictions allow unaccredited energy rating practitioners to practice, the lack of accountability involved, and poor consumer confidence
- Several called for explicit recognition of climate change and the urban heat island effect, and wanted clear recognition of the dangers to human health that 'hot boxes' pose in such circumstances (and also dark roofs)
- Several submissions made references to shortcomings in NatHERS – with many arguing that climate zones or climate files are imprecise or inappropriate in particular locations; some argued that Chenath does not model summer performance, or the actual performance of designs in heatwave conditions, well
- Many submissions noted that some of the treatments noted in the TIC report – such as changing roof colours, window/frame colours, or certain floor treatments, are not well or at all resolved in (at least some) current NatHERS tools, and these would need (minor) improvements to enable this. However, TIC has advised that new versions of NatHERS ratings will address these issue, following changes to the NatHERS software protocol

- Some referred to a lack of consumer awareness around managing over-heating, such as appropriate ventilation/shading strategies, use of blinds, etc, and argued that addressing this would be more effective and cost effective than expensive upgrades, e.g., to glazing
- Some specific/technical points were raised
    - Victorian stakeholders noted that proposed cooling load limits are (considerably) higher than allowed for Class 2s under planning legislation;
    - some argued for load limits to be skewed in favour of improved cooling performance – noting evidence that this is a greater problem than heating performance;
    - one asked whether software tools would allow different mixes of concrete-slab-on-ground and suspended timber floors within the one design, e.g., on sloping blocks;
    - one called for credit to be given for heat recovery ventilation systems/smart ventilation systems
    - other specific solutions were supported – such as reflective foil under tiled roofs and improved ductwork modelling
    - inappropriate climate files for specific locations/climates, as noted above.

5.2.5 Question 5

15 respondents agreed with the annual floor area increases suggested; 1 did not; 3 indicated that it is unknowable or 'no idea'; and 13 offered no views. Several noted that Class 2s are growing much faster than Class 1s, and hoped this was accounted for, while another's support was contingent of the area including the whole area of Class 2s, and not only the ground footprint. These questions, and concerns raised by Master Builders Australia, are addressed in Section 4.1.2 above.

6. Summary and Conclusions

6.1 The Problem

For some time now, industry has expressed the concern that an unintended side-effect of the use of NatHERS as a compliance pathway, without separate heating and cooling load limits, is that has unwittingly allowed designers and builders essentially to trade-off winter and summer performance, potentially to an excessive degree. This means that a small percentage of designs will perform very well in winter but potentially poorly in summer, resulting in designs that are disparagingly called 'hot boxes'. At the same time, a small percentage of designs over-optimised for summer performance can perform poorly in winter, while also demand higher construction costs than would be the case for a better-balanced design.

Analysis by TIC and EES[42] indicates that around 10% of designs are over-optimised for one season but liable to perform poorly in the opposite season.[43] If such dwellings did not have appropriate (and working) building services, occupants could experience poor comfort standards during weather extremes, risking poor health outcomes and a (small) increase in the probability of fatalities.[44] Assuming adequate building services, significant energy consumption may be required to correct for the unbalanced thermal performance. In addition to raising energy costs, this extra consumption may also contribute to demand at times of peak load, requiring additional investment in electricity networks to cover the anticipated load. Finally, the additional energy consumption would generate additional greenhouse gas emissions.

6.2 Objectives

Against this background, the objective is to ensure that the approximately 70% of new dwelling designs that demonstrate compliance with NCC energy efficiency Performance Requirements using NatHERS perform well in both summer and winter. This can be achieved by effecting changes to the small percentage of designs that are over-optimised for one season and which risk to perform poorly in the opposite season. Achieving this would be consistent with improving occupant comfort and amenity while reducing greenhouse gas emissions and using energy efficiently.

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[42] Tony Isaacs Consulting and Energy Efficient Strategies, *Principles and Methodology for Setting NCC Heating and Cooling Load Intensity Limits,* undated; and *The Impact of Heating and Cooling Load Intensity Limits on NCC Compliance,* undated.

[43] Note that this value derives from statistical analysis designed to eliminate only the worst performers. However, performance is a spectrum and different limits could be set. However, as the percentage of the new stock increases, the risk of an unintended change in overall stringency would also increase.

[44] As discussed in Chapter 2, there is a paucity of research with which to correlate fine degrees of change building thermal performance with morbidity and mortality outcomes in Australia. That said, it is very well established that there are additional deaths associated with poor thermal performance, in both cold and hot weather. Therefore, it is reasonable to assume at least a qualitative health benefit associated with improved thermal performance, particularly when focusing on improving 'outlier' designs, as we do here. We do not attempt to quantify such benefits, however.

6.3 Options

We examine three options:

1) Status quo;

2) Regulatory changes within the Code and NatHERS scheme (complemented with education and training);

3) Voluntary changes effected via education and training for energy assessors and other industry professionals.

6.4 Benefit Cost Analysis

The benefits and costs associated with these two options are as set out in Table 16. The regulatory option is expected to generate significantly higher uptake of the required changes and therefore greater net benefits. Option 2, the regulatory approach, is expected to generate $20.6 million in energy and related externality benefits, while also reducing construction costs by some $51 million, leading to a NPV for this option of $71.8 million. By contrast, the lower expected uptake of this measure under Option 3, on a voluntary basis, is expected to generate around $3.9 million in energy and related externality benefits (present value basis, at 7% real discount rate), while reducing construction costs by $10.8 million, leading to a NPV for this option of $14.7 million. Both options have negative benefit cost ratios, reflecting the expectation of reductions in construction costs on average. By implication, Option 1 – the status quo – is associated with an opportunity cost, or foregone economic benefit, of $71.8 million.

Table 16: Summary of Key Indicators – Regulatory vs Non-Regulatory Option

a. Present value of benefits ($'000)

Jurisdiction	Regulatory Option 2	Non-Regulatory Option 3
VIC	$10,174	$1,942
QLD	$2,885	$562
SA	$1,801	$342
WA	$5,150	$981
ACT	$583	$111
Total	**$20,594**	**$3,938**

b. Present value of costs ($'000)

Jurisdiction	Regulatory Option 2	Non-Regulatory Option 3
VIC	-$24,573	-$7,206
QLD	-$6,044	-$2,515
SA	-$1,083	-$533
WA	-$17,938	-$4,653
ACT	-$1,451	-$259
Total	**-$51,090**	**-$15,166**

c. Net present values ($'000)

Jurisdiction	Regulatory Option 2	Non-Regulatory Option 3
VIC	$34,748	$9,149
QLD	$8,928	$3,077
SA	$2,884	$875
WA	$23,089	$5,633
ACT	$2,035	$370
Total	**$71,684**	**$19,105**

d. Benefit cost ratios

Jurisdiction	Regulatory Option 2	Non-Regulatory Option 3
VIC	*negative*	*negative*
QLD	*negative*	*negative*
SA	*negative*	*negative*
WA	*negative*	*negative*
ACT	*negative*	*negative*
Total	*negative*	*negative*

Notes: present values of benefits have been calculated using a 7% real discount rate over the 40 year assumed life of dwellings; while the present values of costs have been calculated using a 7% real discount rate over the assumed 10 year life of the proposed measure.

We find that these results are highly robust in the face of a wide range of sensitivity analyses, including when 'stress testing' the measure by simultaneously assumed least favourable outcomes across a range of sensitivity variables. We find that the only material variable is the extent to which designers and builders choose least cost as compared to higher cost solutions. The measure remains cost effective provided that not more than 25% - 36% of solutions are implemented using the highest cost, as compared to the least-cost, of the solutions identified. In competitive and well-informed markets, we would expect the majority of solutions implemented to be least-cost, and close to 100% of them under the voluntary implementation Option 3.

That said, noting that the changes envisaged are relatively minor, and also that they require a sound knowledge of building physics, there are risks of some higher cost solutions being implemented due to a lack of knowledge or, under Option 3, non-compliance due to cost concerns. An effective information and education campaign would be likely to:

- Under Option 2, increase the likelihood of least-cost solutions being identified and implemented, improving net social welfare, and
- Under Option 3, increase the uptake of the measure, in addition to the selection of least-cost solutions.

The analysis indicates that the benefits associated with an effective information and education program are likely to be valued at many times the cost of providing the program.

6.5 Conclusions

We conclude, firstly, that implementing the measure would be cost effective and generate a material net benefit for society.

Second, implementing the measure via regulation would be considerably more effective than implementing it on a voluntary basis, primarily due to the expectation of much higher uptake of the measure via a regulatory pathway. As a result, the regulatory option generates significantly greater net economic welfare than the non-regulatory option.

Third, whether the measure is implemented voluntarily or by regulation, an effective information and education program is warranted and likely to be highly cost effective.

Finally, we note that implementation of the measure on a regulatory basis is supported by a significant majority of stakeholders, while the same stakeholders express concern about the limited uptake and impact of a voluntary solution.

6.6 Implementation

If the preferred option is implemented, heating and cooling load limits will be referenced in the NCC 2019 as an ABCB Standard. The NatHERS Administrator will engage software developers to include notification prompts to alert assessors about separate load limits required in NCC. In addition to that, a text box for NCC requirements will be showed on NatHERS Universal Certificates with an emphasis on heating and cooling load limits.

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.

6.7 Review and Evaluation

The proposed heating and cooling load limits 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. This is a formal process which requires proponents of change to provide justification to support their proposal.

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 heating and cooling load limits are found to be more costly than expected, difficult to administer or deficient in some other way, it is open to affected parties to 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 and home owners do in fact respond. In order to do this effectively, the ABCB has contacted CSIRO for access to the NatHERS Data Dashboard. The Dashboard is managed by CSIRO for collecting NatHERS data covered on a Universal Certificate including heating and cooling loads. The data will allow the ABCB to compare heating and cooling loads before and after the implementation of the new load limits. The ABCB will also seek regular feedback from industry, building administrators, and the NatHERS Administrator in relation to the implementation of the new requirements.

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Appendix A: Construction cost implications of design changes

Introduction

The TIC report, *The Impact of Heating and Cooling Load Intensity Limits on NCC Compliance,* uses case studies to illustrate the compliance cost of meeting the proposed, separate, heating and cooling load limits. The case studies describe several design change options that could be selected for the 10% of dwellings that would meet the current NatHERS combined heating and cooling limit but fail one of the proposed, separate load limits for heating and cooling. 44 cases are covered.

There are three dwelling types for case studies that fail the proposed cooling load limit:

- One Class 1 dwelling with a timber floor at 6 stars,
- One Class 1 dwelling with a concrete slab on ground floor at 6 stars,
- One Class 2 dwelling with a concrete slab floor – for the minimum allowed 5 star compliance, then:

another three dwellings that fail the proposed heating load limit:

- One Class 1 dwelling with a timber floor at 6 stars,
- One Class 1 dwelling with a concrete slab on ground floor at 6 stars
- One Class 2 dwelling with a concrete slab floor – for the minimum allowed 5 star compliance.

These dwelling types are repeated across 8 climate zones:

- Brisbane, Perth, Adelaide, Sydney, Melbourne, Canberra, Mildura and Hobart[45].

Three or four different design options for bringing the dwellings into compliance with the proposed load limits are presented by TIC.

The construction costs for each design option for each dwelling type and climate was estimated.

The costs include the changes made to the building fabric of each of the dwelling types in order for the heating/cooling load limits to be met. Each option was costed using the relevant state edition of the 2017 *Cordell's Housing Building Cost Guide*. Separate editions for the ACT and Tasmania are not published, however the NSW and Victoria editions provide cost adjustment factors for those jurisdictions.

In most cases, calculating cost changes involved simply looking up the $/m^2 of the relevant building element in the Cost Guide and multiplying it by the quantity of the element. Or, if insulation levels were increased (for example from R2.5 to R3.5), the difference in cost between the two was multiplied by the insulated area.

[45] There are only two cases in Hobart: Heating load for Class 1 dwelling on a timber floor and cooling load for Class 1 dwelling on a timber floor

There were some window changes which couldn't be costed using Cordell's. For example, using a 'manufacturer's window instead of a default window' as well as using a specific brand of window. In these cases, we have used costs from a recent project for which a Quantity Surveyor provided estimates for various window qualities.

One of the changes made for the concrete slab dwellings is to use a waffle pod slab instead of a conventional slab, or vice versa. Which one is cheaper is very site specific, with factors like soil type (and therefore footing design for which we don't have details) and slope, influencing cost. Also, builders tend to have a preference for one over the other, another influencing factor. Given that one slab type may be cheaper than the other in some but not all circumstances we have assumed there is no difference in cost between the two.

Summary of Cost Changes

The tables below provide a summary of costs ($\$/m^2$) of each design change options used to meet the heating or cooling load limits as identified in the TIC report. There are 3 or 4 options per dwelling type.

The left-hand column of the tables describes the options (alternative means of changing the design to meet the proposed heating/cooling load for that dwelling type in that climate zone). The right-hand column shows the construction cost of the options. Where the cost is negative it means the change will reduce the total cost of the dwelling. A positive figure indicates that the option will increase the construction cost.

It is clear that there can be a significant difference between the lowest and highest cost solutions. In general, reducing glazing area and/or reducing window performance are the lowest cost solutions (they are negative cost). On the other hand, installing external blinds, using tiles in lieu of carpet and improving window performance are amongst the highest cost solutions.

Note that least-cost solutions are identified in green, while highest-cost solutions are identified in orange.

Brisbane

Measures and cost to comply with heating load limit:

Class 1 dwelling on a slab on ground floor

OPTIONS	$/m²
A: Increase wall insulation: add R2.7 batts behind foil	17.9
B: Increase ceiling insulation from R1.5 to R2.0 and use medium colour roof sheet instead of light colour	1.8
C: Reduce eaves from 750 to 450mm and use medium coloured roof	-5.2
D: Use clear glazing instead of tinted glazing	-20.3

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Reduce overhangs to 600 from 1000. Use dark window frames instead of light window frames and replace 3700 mm of roof over deck with adjustable horizontal device	2.0
B: Reduce glass area by 5.7 m² (still has a 38% window to NCFA ratio), use clear glass instead of tint and use dark window frames instead of light	-32.0

Class 2 dwelling on a concrete floor

OPTIONS	$/m²
A: Increase roof insulation to R2.5	2.4
B: Add R 1.0 insulation to wall	7.4
C: Use low e coated tinted glazing	19.1
D: Use clear rather than tinted glazing	-4.2

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a concrete slab on ground floor

OPTIONS	$/m²
A: Ceiling fans to all living rooms, bedrooms and study (10) and light coloured roof	9.1
B: Tiled floors to kitchen/family, living room, study and hall, light coloured roof	8.2
C: Add 450 eaves, Increase roof insulation from R3.0 to R3.5, external blinds to west windows in Kitchen/Family room (15 m²)	4.5

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Comfort plus single glazing with a light coloured frame and a light roof colour	-31.8
B: Reduce roof insulation to R4.0, add reflective foil under tiles and ventilators to the roof. Use a light window colour	2.3
C: Change windows to single glazed clear with light frames and provide external blinds to all east and west windows in the kitchen/family, lounge and bedroom 1 (18.4 m²)	-15.9

Class 2 dwelling on a concrete floor

OPTIONS	$/m²
A: Use tinted windows	19.0
B: Add ceiling fans to all rooms	11.1
C: Use ceramic tiles to the slab in the living room	12.5
D: Provide external blinds to two of the west windows in the living room (16m²)	2.47
Zero/least cost options: • Change window frame colour from dark to light. This allows the wall insulation to be reduced from polystyrene board to foil on inside of plasterboard. • Increase size of ceiling fan in the living area from 900 mm to 1400 mm and add a 1200 mm fan to bedroom 1. This also allows the wall insulation to be reduced from polystyrene board to foil on inside of plasterboard. • Replace timber floor covering to living area with ceramic tiles and use a medium coloured external wall instead of dark. This allows the wall insulation to be reduced from polystyrene board to foil on inside of plasterboard.	0.0

Perth

Measures and cost to comply with heating load limit:

Class 1 dwelling on a slab on ground floor

OPTIONS	$/m²
A: Replace Comfort Plus tinted glazing to north and south elevations with a single low- e glazing which has a high solar transmission like Energy Advantage. Because north and south windows have lower solar gains in summer the cooling load is barely affected by the change.	3.0
B: This is a passive solar house. If sited to face north the house achieves a 7-star rating and cooling loads are also reduced.	0.0

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Increase ceiling insulation to R4.0, a medium coloured roof, and use low-e coated high solar transmission glazing like Energy Advantage to living areas (19.5 m²)	7.5
B: Use dark coloured bricks (e.g. Red) and dark coloured window frames	0.0

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a concrete slab on ground floor

OPTIONS	$/m²
A: Use a conventional uninsulated slab instead of a waffle pod slab, light coloured window frames, external blind to west window in the kitchen (4 m²), reduce wall insulation to R1.5, reduce ceiling insulation to R3.0	-19.6

B: Use comfort plus glazing, light coloured window frames, reduce wall insulation to R1.5, external blind to west window in the kitchen (4 m^2), reduce ceiling insulation to R2.5	18.1
C: If it is possible, wall change the construction to brick cavity (uninsulated). With no other changes the house would achieve 7 stars	N/a

Class 1 dwelling on a timber floor

OPTIONS	$/m^2
A: Use ceiling fans to sitting room and bedrooms, 3 ceiling fans to the Kitchen/Living area. Rating is now at 6.5 stars which would allow brick cavity insulation to be removed and still comply.	-8.8
B: Add external blinds to clerestory windows and East window in Living room. This allows insulation to be removed from brick cavity external walls.	-9.7
C: Remove floor insulation. Add 3 ceiling fans to the Living/Kitchen and 1 to Sitting rooms. Remove external wall insulation to brick cavity walls	-23.8

Class 2 dwelling on a concrete floor

OPTIONS	$/m^2
A: Reduce full height glazing from 2.6m to 2.1 m. – a reduction in the total glazing area of 9 m^2	-24.2
B: Use light coloured walls and light coloured window frames, provide 1 external blind to the west (4 m^2)	2.6
C: Provide 3 ceiling fans to the living room and one each to the bedrooms	12.0
D: Use ceramic tiles to living/kitchen and hall/study instead of carpet	20.2

Adelaide

Measures and cost to comply with heating load limit:

Class 1 dwelling on a slab on ground floor

OPTIONS	$/m^2
A: Use actual manufacturer's windows in the rating rather than defaults with clear glazing (in this case A&L windows were used). Cooling loads increase to 32 MJ/m^2. This can be reduced back to the original load through the use of light coloured window frames and using some low-e single glazing if required, however, even 32 MJ/m^2 is not a large cooling load.	0.0
B: Select a lot where the backyard faces north.	0.0
C: Use actual manufacturer's windows in the rating with high solar gain single low-e glazing. The house now obtains a 6.9 star rating. This would allow a reduction in wall insulation to R1.5 and ceiling insulation to R2.0 to still easily meet 6 stars to offset the cost of the low e coated glazing. Cooling loads only increase by 10% with this option.	14.9

Class 1 dwelling on a timber floor

OPTIONS	$/m^2
A: Use actual manufacturer's windows in the rating rather than defaults with clear glazing (in this case A&L windows were used). Cooling loads increase by 20%.	9.8
B: Use dark brick and window frame colours.	0.0

C: Use foil backed polystyrene insulation in the walls and dark coloured window frames.	15.1

Class 2 dwelling on a concrete floor

OPTIONS	$/m²
A: Use manufacturer's actual window product in the rating. Sliding door to Living must be double glazed with low-e coating and argon fill, but all other windows can be single glazed low-e with a high solar transmission coating. Increase R-value in walls to R1.5 and use dark coloured window frames.	-27.4
B: Reduce height of full height windows from 2880mm to 2100mm (7m² reduction window to NCFA ratio becomes 26%)	-26.3

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a concrete floor

OPTIONS	$/m²
C: Reduce floor insulation. Reducing the R-value to R0.5 from R1.5 strikes a balance between increases to heating and reduction to cooling loads but still requires additional measures: use white window frames to reduce heat gain through the frame.	-5.2
D: Using real manufacturer's windows improves performance. By using low-e 'Planitherm' coated windows (which have a significantly lower heat loss and a lower heat gain than default windows) in the lower floor and upper floor retreat all other windows to the upper floor can be single glazed.	0.0

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Provide an Alfresco area in the position shown on plan but use an adjustable horizontal blind that can be drawn back in winter	27.7
B: Provide external blinds to west windows in the family and games rooms (2 windows 8.3 m²)	2.4
C: White framed windows and ceramic tiles in the Games room	2.4
D: Insulate the subfloor walls rather than the floor itself.	-1.4

Sydney

NB: NSW is not included in the regulatory proposal, as separate load limits already apply under BASIX. The analysis is shown for completeness only.

Measures and cost to comply with heating load limit:

Class 1 dwelling on a slab on ground floor (Climate 28)

OPTIONS	$/m²
A: Replace comfort plus glass with clear Energy Advantage low-e glass which has a higher solar heat gain.	4.5
B: Reduce south facing glazing in the kitchen/family room by 4 m².	-3.6

C: Increase wall insulation to R2.7 plus low emissivity anti-glare reflective foil and increase ceiling insulation to R5.0.	6.4

Class 1 dwelling on a timber floor (Climate 28)

OPTIONS	$/m²
A: Insulate subfloor walls with R1.0 polystyrene insulation (note: does not block subfloor vents)	3.9
B: R2.5 wall insulation and lower emissivity anti-glare reflective foil.	3.6
C: Use louvre windows with a higher heat gain: SHGC 0.44 instead of 0.37.	8.7
D: Trim south glass area by 4 m^2 and use a higher solar transmission low-e coated sliding door (Energy Advantage instead of Comfort Plus).	2.2

Class 2 dwelling on a concrete floor (Climate 17)

OPTIONS	$/m²
A: Use a clear low-e glazing with a higher solar heat gain. Most of the windows face south so the lower heat gain glass is not needed	19.0
B: Reduce height of full height windows from 2880mm to 2700mm (1.5m^2 reduction)	-4.3
C: Use dark window frames and walls (instead of light/medium) and increase wall insulation to R2.0	8.9

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a slab on ground floor (Climate 28)

OPTIONS	$/m²
A: Use a conventional slab instead of a waffle pod slab. Insulating under the concrete floor reduces the ability of the house to lose heat to the ground in summer. Use light coloured window frames, use tiles in the Games room and living instead of carpet	3.8
B: Use a conventional slab instead of a waffle pod slab, a light-coloured roof and provide two external blinds to west facing windows in the kitchen/family area (8.6 m^2)	6.4
C: Use a tinted low-e glazing product instead of clear and a medium coloured roof instead of dark	9.9
D: Ceiling fans to all living and bedrooms (11 x 1400 mm)	9.8

Class 1 dwelling on a timber floor (Climate 28)

OPTIONS	$/m²
A: Ceiling fans to all living and bedrooms (11 x 1400 mm)	23.3
B: Use a light-coloured roofing, provide ventilators to roof space, use light coloured window frames	3.1
C: Combining either of the two strategies above with R2 subfloor wall insulation would allow wall insulation to be reduced to R1.5 and ceiling insulation to R4.0 and eliminate double glazing	-11.3
D: Provide external blinds to all east and west windows of habitable rooms (8, 24.1 m^2)	16.8

Melbourne

Measures and cost to comply with heating load limit:

Class 1 dwelling on a concrete slab on ground floor (Climate 60)

OPTIONS	$/m²
A: The cheapest way to comply is to find a lot which allows the house to face north at the rear.	0.0
B: The house was rated with default windows. These windows are at the bottom end of performance, although a significant proportion of NatHERS assessors still only use default windows. Using an actual manufacturer's product improves the rating to 6.3 stars and achieves compliance with the heating load limit.	0.0
C: Floor insulation is set to R0.5 which is equivalent to the insulation provided by a 175mm waffle pod slab. This R value is typical of slab floors with in slab heating. Use of a 375mm waffle pod slab (or increasing insulation under the slab to R1) would reduce heat loss through the slab and allow compliance	8.2
D: Use a dark roof colour and dark coloured window frames.	0.0

Class 1 dwelling on a timber floor (Climate 60)

OPTIONS	$/m²
A: Replace default double glazed windows with actual manufacturer's product. In this case only 3 windows would need to be double glazed with high performance double glazing in the kitchen family room – all other windows can be single glazed (10.3 m²).	-14.2
B: In cooler climates insulating subfloor walls is not as effective at reducing heating loads. Install R1.0 insulation under the floor and remove subfloor wall insulation.	11.3
C: Use a dark roof colour and dark window frames.	0.0

Class 2 dwelling on a concrete floor (Climate 60)

OPTIONS	$/m²
A: Use dark coloured walls with R2.5 insulation and add foil to the existing air space and dark coloured window frames.	7.1
B: Reduce height of all full height windows from 2600mm to 2400mm (4m² reduction in area) and use darker coloured frames.	-6.0
C: The unit is rated with default windows. Use actual manufacturer's product with dark frames.	0.0

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a concrete slab on ground floor (Climate 60)

OPTIONS	$/m²
A: Use tiled floors throughout the ground floor to allow the thermal mass of the slab floor to be absorb and moderate summer solar heat gains.	14.1
B: The cheapest solution is always to match the house to the site. The house was design to face north and achieves 6.4 stars when it does. This provides scope to lower other specifications to reduce construction costs.	0.0
C: Provide external blinds to 5 east/west windows (24 m^2). This increases the rating to 6.3 stars and this additional performance can be used to lower specifications and save cost. For example, the R1.5 rigid board slab insulation could be replaced with a cheaper waffle pod insulation system.	9.4

Class 1 dwelling on a timber floor (Climate 60)

OPTIONS	$/m²
A: Replace default double glazed windows with actual manufacturer's product. In this case only 3 windows would need to be double glazed with high performance double glazing in the kitchen family room – all other windows can be single glazed (10.3 m^2).	-14.2
B: In cooler climates insulating subfloor walls is not as effective at reducing heating loads. Install R1.0 insulation under the floor and remove subfloor wall insulation.	11.0
C: Use a dark roof colour and dark window frames.	0.0

Class 2 dwelling on a concrete floor (Climate 21)

OPTIONS	$/m²
A: Use light coloured roof, walls and window frames and provide 1 external blind to a north west window (5.8 m^2).	7.2
B: Provide a covering to the balcony similar to lower floors	110.9
C: Provide 3 external blinds to the largest living area windows (24.6m^2)	30.4
D: Significantly reduce the glazing area from 43 m^2 to 30 m^2. The unit now achieves a 6 star rating. This would allow a 5 star rating and cooling load compliance to be achieved with only single glazed low-e glazing to the living area windows and single clear glazing to the bedrooms.	-77.2
C: Improve air flow by using a stacker door to the balcony that opens up to two thirds of its width and provide ceiling fans in the kitchen/living (3) and bedrooms (1 each).	33.4

Canberra

Measures and cost to comply with heating load limit:

Class 1 dwelling on a concrete slab on ground floor

OPTIONS	$/m2
A: Removing the eaves from east, south and west walls achieves compliance with the heating load limit.	-8.2
B: Remove the 900 mm overhang to the north facing clerestory windows and replace with adjustable external blinds. This significantly improves the rating and would allow the house to be built without as much double glazing at minimum compliance levels.	Need more info to cost
C: The south facing mud brick walls receive little sun in winter so these have the greatest heat loss. Replace these walls with framed insulated construction. 80% of internal and external walls are still constructed of mud brick. This improves the rating to 6.7 stars, and again would allow the house to be built with less double glazing to achieve minimum compliance.	Need more info to cost

Class 1 dwelling on a timber floor

OPTIONS	$/m^2
A: Use a dark coloured roof. Note that roof ventilators may be removed because they do not significantly impact cooling loads.	2.2
B: Use dark coloured window frames	0.0
C: Double glaze the sliding door to the kitchen family (or another window(s) of equal area if required	4.6
D: Flip the plan so that the kitchen living are has north windows rather than the Theatre room	0.0

Class 2 dwelling on a concrete floor

OPTIONS	$/m^2
A: Use clear glazed windows rather than tinted windows. This may conflict with aesthetic requirement to have the same glazing colour on all facades. This measure does significantly improve the rating from 5 to 5.4 stars and would allow other specifications to be reduced as well.	-20
B: Use dark coloured window frames.	0.0
C: Reduce height of all full height windows from 2600mm to 2400mm (4m^2 reduction in area) and use darker coloured frames.	-4.3

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a concrete slab on ground floor

OPTIONS	$/m²
A: Tile the whole Kitchen/Family area to give better access to the thermal mass in the slab and install 2 x 1400 mm ceiling fans in this room	9.0
B: Use a light-coloured roof and window frames, reduce the width of the two 3300 mm wide windows in the Kitchen/Family room to 3000 (a reduction of only 1.2 m^2).	-2.9
C: Install two external blinds to large west facing windows in the kitchen family room (14 m^2). This increases the rating to 6.3 stars which allows wall insulation to be reduced to R1.5 instead of the more expensive R2.7 batts to help offset the cost of the blinds.	3.5

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Use light coloured roof and window frames and provide 3 x1400mm ceiling fans to the Kitchen/Family room and 2 to the upper living room	4.6
B: Provide 7 external blinds to east and west windows in living areas (32.1 m^2) and two ceiling fans to the upper living room.	11.6
C: Remove floor insulation and insulate subfloor walls instead (leave subfloor vents exposed) and make window frames and roof a light colour. This will reduce construction cost and meet the cooling load limit but does increase heating loads by 25% so may not be acceptable.	0.0
D: Use light coloured roof and window frames and provide tiles instead of carpet to the Lounge, Kitchen/Meals and Games rooms.	11.7

Mildura

Measures and cost to comply with heating load limit:

Class 1 dwelling on a concrete slab on ground floor

OPTIONS	$/m²
A: Use dark coloured roof and window frames. Trim south and west glass facing the courtyard by 1.5m^2. Cooling loads increase by 20% from a low level.	-4.5
B: Use low-e single glazing with a higher solar heat gain (particularly on northern facing windows) and a medium coloured roof.	6.7
C: Increase roof insulation to R5.0, use a dark roof, medium coloured window frames and reduce glazing area by 2.5m^2.	-5.5
D: Use dark coloured floor tiles, roof and window frames. This increases cooling loads by 20% from a low level.	0.0

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Insulate the subfloor walls with R2.0. This lowers heating loads without affecting cooling. Use dark coloured window frames and roof.	8.3
B: Select a lot where the backyard faces north.	0.0
C: Insulate floor with reflective foil. This increases cooling loads by 40%, however the rating is now 6.6 stars so other elements could be de-specified to provide more shade to deal with cooling loads or to offset the cost of floor insulation (walls need only use R1.5 insulation if the floor is insulated).	2.2
D: Use higher performance double glazing in the kitchen/family room (argon fill). This can significantly increase the rating allowing the owner/builder to de-specify other parts of the building to offset the cost of the higher performance glazing	28.4

Class 2 dwelling on a concrete floor

OPTIONS	$/m²
A: Use dark coloured window frames and add reflective foil to airspace in external wall	7.0
B: Reduce height of full height windows from 2700mm to 2400mm (4m² reduction window to NCFA ratio becomes 28%).	-8.0
C: Use low-e single glazing without a tint (dark frames).	-19.0

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a concrete slab on ground floor

OPTIONS	$/m²
A: Ceiling fans to all living rooms, bedrooms and study (10).	9.0
B: Use a conventional slab. The insulation of the waffle pod slab reduced its ability to lose heat to the cooler ground and in Mildura only reduces heating loads by 10%. Use medium coloured window frames instead of dark.	0.0
C: Tiled floors to kitchen/family, living room, study and hall.	14.0
D: Add 450mm eaves, external blinds to west windows in Kitchen/Family room (15 m²)	5.0
E: Use a light coloured roof and window frames	0.0

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Insulate the subfloor walls with R2.0 and take out the R3.0 under the floors.	-4.0
B: Provide ceiling fans to Kitchen/Family, Games, lower and upper living rooms (9 x 1400 mm).	8.0
C: Use a light coloured roof and window frames	0.0
D: Provide external blinds to all east and west windows of habitable rooms and ceiling fans to the Kitchen/Family and Games rooms (5 x 1400 mm)	11.8

Class 2 dwelling on a concrete floor

OPTIONS	$/m²
A: Use light-coloured windows	0.0
B: Install 1 external blind to the large west facing window in the living area (13 m^2)	8.4
C: Use a light-coloured roof and medium coloured window frames	0.0
D: Use a tiled floor	47.6
E: Reduce height of all full height windows from 2600mm to 2100mm (7m^2 reduction in area)	-13.7

Hobart

[NB: Tasmania is not proposed to be included within this potential regulatory change]

Measures and cost to comply with heating load limit:

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Use dark coloured roof and window frames	0.0
Double glaze 2 windows in the Kitchen/Family area (5.6 m^2)	4
B: Increase floor insulation to R2.0	0.8
C: Increase ceiling insulation to R5.0	5.5

Measures and cost to comply with cooling load limit:

Class 1 dwelling on a timber floor

OPTIONS	$/m²
A: Use white coloured window frames, and reduce west facing glazing by 3 m^2	-5.4
B: 2 m deep eaves on the west and east side of the building. This virtually eliminates cooling altogether but does increase heating. To meet the load limit eaves need only be 1 m deep.	5.5
C: External Blinds to all windows in the Kitchen/Family and Theatre rooms	10.4

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