Evaluation of the Victorian 6-star Housing Standard

- **Final Report**

Prepared for:	**Department of Environment, Land, Water & Planning**
Date:	**July 2019**

Revision History					
Rev No.	Description	Prepared by	Reviewed by	Authorised by	Date
00	Draft Report	PH	MR	PH	6/8/2018
01	Exposure Draft Final	PH	MR	PH	7/11/2018
02	Final Report	PH	MR	PH	11/1/2019
03	Final Report (rev.)	PH		PH	12/6/2019
04	Final Report (rev.)	PH		PH	24/7/2019

Table of Contents

Index of Figures

Index of Tables

Appendices

Executive Summary

This study evaluates the public and private benefits and costs that have been generated by:

- Victoria's 6-star energy performance standard for housing, that has applied since mid-2011, including the lighting energy performance requirements;
- The State Code variation that requires new Class 1 buildings to have either a rainwater tank connected to all sanitary flushing systems, or a solar water heater system, installed in accordance with Victoria's plumbing regulations.[1]

It also explores how the Victorian building industry has responded to the Victorian 6-star standard in terms of (e.g.) design or specification changes and changes in business-as-usual inclusions, including through detailed consultations with a wide range of stakeholders.

The evaluation assumes that the measures apply from the date of their actual commencement (July 2005 and May 2011 respectively) until the end of the 2019 financial year (FY2019). The measures may continue to apply in future, in which case both new benefits and new costs will continue to arise.

Generally, the investments induced by these measures have economic lives that extend well past FY2019, and this is taken into account when estimating the future benefits. The base or reference case is a counter-factual scenario that assumes that the pre-existing 5-star housing remained in place until FY2019 and that the plumbing regulations were not introduced in 2005. In this counter-factual scenario, we assume that Victoria would have introduced similar provisions to other states in 2011 that effectively banned electric storage hot water systems in new residential developments.

The study finds that the 6-star energy performance standard and solar hot water heater option under plumbing regulations have been highly effective in generating significant resource and emissions savings, and highly cost-effective for consumers and the wider public benefit. The economic and environmental benefits will continue on past 2050.

The peak *annual* impacts of the measures include 3.7 PJ of avoided energy consumption and 341 kt CO_2-e of avoided greenhouse gas emissions. In cumulative terms over the 2006 – 2058 period, the measures will save more than 114 PJ of energy and 8.7 million t CO_2-e of greenhouse gas emissions over the economic lives of the investments induced. Details are shown in Table 1.

[1] This report focuses on energy-related impacts and does not quantify outcomes relating to rainwater tanks.

	Units	Cumulative to 2058	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2058
Energy Savings														
6-star	TJ	81,659			1,052	2,041	2,041	2,041	2,041	2,041	2,041	2,041	989	252
Lighting	TJ	155			5	10	10	5						
Solar Hot Water	TJ	32,620	42	529	1,169	1,631	1,631	1,102	462					
Total:	TJ	**114,435**	**42**	**529**	**2,226**	**3,683**	**3,683**	**3,149**	**2,503**	**2,041**	**2,041**	**2,041**	**989**	**252**
Greenhouse Gas Emissions Savings														
6-star	t CO2-e	6,276,385			137,864	204,523	195,096	192,484	171,062	133,233	96,855	86,127	41,362	10,383
Solar Hot Water	t CO2-e	2,441,229	3,201	50,371	102,006	117,076	113,941	75,026	29,389					
Total	t CO2-e	**8,717,614**	**3,201**	**50,371**	**239,870**	**321,598**	**309,037**	**267,509**	**200,451**	**133,233**	**96,855**	**86,127**	**41,362**	**10,383**

Table 1: Summary of Resource and Emissions Savings: All Measures: Selected Years

Benefit Cost Analysis

On the basis of public benefits and costs (that is, taking into account 'external' benefits and costs that fall on parties other than those directly affected by the measures, including the environment), the package of measures has delivered an increase in net economic welfare of almost $1.9 billion – see Table 2. This figure comprises a present value of all quantifiable benefits just under $3.5 billion and a present value of costs of under $1.9 billion. This creates a public benefit cost ratio (BCR) of 2.2 and a rate of social return on investment of 11% per annum for the package as a whole. We assess these outcomes as significant and *highly* cost-effective.

FY2019$m real, 4% real discount rate	6 Star (incl. lighting)	Solar Hot Water	Totals
Public Benefits	$2,593	$883	$3,476
Public Costs	$977	$634	$1,611
Net Present Value (NPV)	$1,616	$249	$1,865
Benefit Cost Ratio (BCR)	2.7	1.4	2.2
Internal Rate of Return (IRR)	13%	9%	11%

Table 2: Summary of Public Costs and Benefits

Within the overall public benefit cost results, Table 2 also shows that there is variation in the degree to which each element is effective and cost-effective. The 6-star standard, including lighting, makes the largest contribution to the net social benefit ($1.6 billion), and does so with a very healthy BCR of 2.7 and a higher IRR of 13%.[2] The solar hot water element makes the smaller contribution to the net social value ($249 million) and has a lower BCR of 1.4, with an IRR of 9%, although this is comfortably cost-effective.

The relatively lower net benefits associated with solar hot water reflect the relatively high cost of gas-boosted solar, compared to other hot water technologies, combined with modest energy savings, particularly as we apply data that suggests that hot water consumption is lower in Victoria than assumed in national standards. This also means that opportunities to save energy associated with hot water use are proportionately lower.

Considering only the subset of these benefits that accrue to, and costs that fall on, households – also known as *private* costs and benefits – the package of measures has delivered net *private* benefits of nearly $1.3 billion. This includes a present value of private benefits of nearly $2.7 billion and a present value of private costs of just under $1.4 billion. This generates a private BCR cost ratio of 1.9 and an annual private return on investment of 11% per annum - see Table 3.

[2] BCR values above 1 are considered cost-effective.

FY2019$m real, 4% real discount rate	6 Star (incl. lighting)	Solar Hot Water	Totals
Private Benefits	$1,832	$819	$2,651
Private Costs	$977	$420	$1,396
Net Present Value (NPV)	$855	$400	$1,255
Benefit Cost Ratio (BCR)	1.9	2.0	1.9
Internal Rate of Return (IRR)	8%	14%	11%

Table 3: Summary of Private Costs and Benefits

The absolute value of private net benefits is lower than the value of public net benefits because environmental and other 'external' benefits (such as avoided electricity network and shadow carbon costs) are not included in the private benefits indicator. Private costs are also a little lower, for the solar hot water measures, due to the cost of subsidies being excluded from this analysis, as subsidies represent a cost to the taxpayer, and so are counted under public costs. As a result of this, it may be noted that the private *net* benefit for the solar hot water heater aspect of the package is higher than the public net benefit.

Most importantly, however, the measure remains robustly cost-effective on a private as well as a public basis. An 11% annual rate of return on investment is many times higher than available on term deposits, for example, and the savings are effectively locked in for decades.

Non-quantified benefits that may be associated with the package of measures include the higher comfort, thermal resilience and potentially health benefits associated with the more energy-efficient 6-star housing cohort. However, such benefits cannot be quantified easily.

Sensitivity Analysis

Sensitivity analysis aims to establish how sensitive are the headline or central estimates to plausible ranges of outcomes for significant or 'driver' variables. The intent is to determine how robust is the net benefit associated with the measures if certain things go worse or better than expected.

For the 6 Star measure, increasing the reference incremental construction cost values by 25% in all time periods, for example, has the effect of reducing the public NPV (of the 6-star measure only) from $1.3 billion in the central case (BCR=2.1) to a still very creditable $1.03 billion (BCR=1.7). If incremental construction costs were instead 25% lower than assumed in all periods, this would increase the public NPV to $1.65 billion and BCR to 2.8. Varying shadow carbon prices, within the ranges examined in this study, has no material impact on the results, as these prices are low relative to other values such energy prices or construction costs.

The solar hot water provision offers the smaller public net benefit of the measures analysed, with a central case benefit cost ratio of 1.4, while the private net benefit is boosted by the availability of subsidies from the (national) Small Technology Certificates scheme. Using three different cost/benefit estimation approaches, two generated very similar results (social BCR of around 1.4) and one a negative NPV and (social) BCR of 0.4. The variation in results is due to differing assumptions about the average volume of hot water consumption in Victorian households and, therefore, different amounts of hot-water-related energy savings per year. This may suggest that the degree of cost-effectiveness of the solar hot water option will vary by household and could fall below a threshold of cost-effectiveness in some cases, even if the average household is just better off due to this element. The plumbing regulations allow purchases of new Class 1 dwellings to choose between solar hot water and rainwater tanks, and this gives greater scope for outcomes that better align with individual preferences. For example, a household that expect to use very little hot water might opt for a rainwater tank instead.

Overall, the only sensitive *assumption* – not variable – is the real discount rate. Discount rates cannot be estimated in advance and then verified in retrospect; rather, they are strictly methodological assumptions. We observe that changing the assumed real discount rate in this study significantly affects the present value of net benefits. At a 7% real discount rate, for example, the public net benefit associated with the package falls to $758 million (from $1.9 billion, so a large fall, but also still a large net benefit), with a BCR of 1.6. Conversely, the NPV rises to $5.8 billion (BCR=3.9) if no discounting is applied at all. The net *private* benefit falls to $361 milllion at a 7% real discount rate (BCR=1.3) and rises to $4.3 billion (BCR=3.7) at a zero real discount rate. Most importantly, the measure remains cost-effective with a range of plausible real discount rate assumptions. The sensitivity arises because most of the additional costs are invested in the early years, while the resulting benefits are spread out over time. Higher real discount rates minimise the present value of impacts (costs and benefits) that occur in the more distant future relative to those that occur in the nearer term. Zero discount rates treat costs and benefits as equivalent regardless of whether they occur in the near or longer term.

Industry Impacts

The impacts of these measures on Victoria's building industry and other stakeholders have been assessed qualitatively through consultations with stakeholders; through our literature review; and via analysis of the quantitative data sets and simulation modelling results. The key changes that have been made to dwellings to comply with the 6-star standard include lifting roof insulation from R4 to R5 or R6 (depending upon the climate zone); lifting wall insulation levels from R1.5 to – R2.0 or R2.5; some use of double glazing in place of single glazing; and potentially low-emissivity glazing in more challenging applications such as corner apartments.

Stakeholder consultations, and also independent costings commissioned in association with the simulation modelling, both indicate that cost increases associated with the 6-star standard were modest. Cost increases on average were less than $1,000 per apartment; less than $2,000 per house; but between $2,000 and $4,600 per duplex townhouse – at least for the reference design studied. Townhouses typically have a higher façade-to-floor-area ratio than houses or apartments, meaning that higher performance facades are required to deliver the same comfort outcomes, while mid-terrace townhouses have similar façade-to-floor-area ratios to mid-level apartments.

The benefit cost analysis indicates that the value of social benefits is much more than double that of costs, while the value of private benefits is also close to double that of private costs.

The rate of industry learning associated with the 6-star standard – leading to real cost reductions over time – is not strongly indicated in this study. This is because there is little data available about actual construction costs and how these may have changed over time. We examine cost data from the original regulation impact statement from 2009, and commissioned specialist firm, Evissa Pty Ltd, to quantify current incremental costs. We sought cost data from stakeholders consulted, but only qualitative observations were offered.

Overall, it appears that incremental construction costs fell by 2.4% *per year* for houses and 13% per year for apartments, but may have risen for townhouses by 8.6% per year. We have lower confidence in the latter result, however, as the townhouse designs modelled in the two time periods are different. Had the 2009 and 2018 townhouse costings been made on a comparable basis, or more data points available, we would expect a similar cost reduction over time as for houses, primarily because high-performance glazing costs have fallen over time.

Stakeholder Perspectives

Despite the positive quantitative findings above, some of the comments received from stakeholders were critical of aspects of the policy package.

In particular, there appears to be a near-universal view that compliance with the requirements is poor and unenforced. However, there is not in Victoria, nor in any other state, a practice of conducting routine compliance audits that might enable the extent of any non-compliance to be quantified. A current round of audits by the Department and VBA will help to inform this issue, but the results are not yet available.

A particular concern expressed by many stakeholders is that the solar hot water requirement may be encouraging cheaper, relatively inefficient flat-plate solar hot water systems that are claimed to have poor reliability and lifespan relative to newer collector designs. This may reflect system choices being made by developers and builders, without the exercise of choice by the end consumer/house owner. Others expressed scepticism of the performance claims made for key building elements, such as double-glazing. Many stakeholders were also critical of Victoria's practice of allowing unaccredited practitioners to operate as energy assessors and building inspectors.

Some stakeholders expressed concern that the solar hot water requirements appear to discriminate in favour of gas and against highly efficient electrical systems, including electrically-boosted solar and heat-pump-based technologies. This was considered to be increasingly at odds with household investment in solar PV systems, which brings opportunities this brings for low-emission consumption of electricity, storage of surplus PV generation in hot water systems, and other more contemporary energy management solutions.

In terms of the 6-star requirement, consultations pointed to the high and uncertain cost of high-performance glazing, the lack of local manufacturing of high-performance glazing, and the generally poor performance of typical window frame solutions available in the market.

While some of the stakeholder comments document may refer to wider issues, and factors not directly attributable to 6-star, they do help to shape industry opinions about the value of the 6-star standard, and may impact negatively (and inaccurately) on perceptions about the overall value of energy performance regulation for housing, despite the quantitative results reported here.

Data Limitations and Confidence

A number of data limitations are discussed in Chapter 2 and, in more detail, in Chapter 6. The most significant limitation is the absence of measured energy consumption data (by fuel) for the 6-star and 5-star dwelling cohorts. We therefore rely primarily on NatHERS ratings data as the key indicator of the change in energy performance induced by the 6-star standard. The implied assumptions include:

1. that compliance with 6-star is at least no worse than it was for 5-star
2. factors such as thermostat set-points, occupancy levels and zoning behaviours are comparable between the 6-star dwelling cohort and those complying with the previous 5-star standard.

The lack of measured energy consumption data also meant that data on the space conditioning, hot water and lighting mix of 6-star housing had to be sourced, or else assumptions made. Data from the Built Environment Sustainability Scorecard (BESS) provided high-quality information, but with a limited sample of years and relatively less coverage of detached housing. Lighting and hot water analyses rely primarily on consultation with government and industry stakeholders, along with general market and technology trends, due to a lack of data specific to the 6-star cohort.

Overall, the data limitations do not prevent robust conclusions being drawn regarding the impact of the 6-star standard and solar hot water option under plumbing regulations – primarily because the overall package of measures is, as noted, highly cost-effective, with these results remaining robust in the face of reasonable sensitivity analysis. At the same time, the data limitations have posed a significant challenge for this evaluation, and we recommend that greater efforts are made to actively collect the data required to evaluate future energy performance standards during the period of application of those standards, rather than in arrears.

1. Background

1.1 Purpose and Scope

The purpose of this study is:

- To evaluate the private and societal benefits and costs of the current 6-star Victorian energy performance standard for new building work, in relation to standards that were in place previously; and
- To understand in detail how Victorian building industry has responded to the Victorian 6-star standard in terms of (e.g.) design or specification changes and changes in business-as-usual inclusions.

The 6-star standard is one compliance option under the Building Code of Australia, introduced in 2010 (BCA 2010), and which still applies today as one volume of the National Construction Code (known as NCC or 'the Code'). Building owners can choose to demonstrate compliance with the Code by submitting their design for rating under the Nationwide House Energy Rating Scheme (NatHERS) and achieving at least a 6-star rating. For apartment buildings, the apartment units must average 6 stars, but individual apartments may be as low as 5-stars within that average (meaning that others will be above 6 star). Alternative compliance pathways include 'deemed to satisfy', which applies a set of prescriptive requirements for elements such as windows and insulation, or alternative solutions that are deemed equivalent to DTS. In practice, it is estimated that close to 100% of new housing in Victoria demonstrates compliance using the 6-star method, while smaller alterations and additions often use the DTS pathway. More details are provided in the Background section below.

The lighting energy efficiency provisions that were introduced in BCA2010 are also considered in this evaluation. These essentially require that installed (wired in) lighting systems have a lamp power density of not more than 5W per sqm.

The project also examines the variation to the BCA that took effect, in Victoria only, from 1 July 2005, and which requires the inclusion of either a rainwater tank plumbed to all sanitary flushing systems or a solar hot water system for new Class 1 dwellings. The scope of this report, as noted, is limited to the solar hot water option.

The study considers building industry practices including:

- Design responses, such as improvements to orientation and form vs incremental increases to insulation and glazing specifications;
- Market transformation, such as the degree to which rainwater/solar water heater requirements have impacted industry; the rate of adoption of double and low-e glazing and other innovations;

- Occurrence of new dwellings that exceed the minimum standard;
- Prevalence of non-NatHERS solutions (e.g. the use of deemed-to-satisfy in preference to a NatHERS rating, verification methods using a reference building);
- Prevalence of dispensations and non-compliance (noting that DELWP is also delivering another project dealing with as-built compliance);
- Prevalence of alternative solutions to the Victorian variation (e.g. the use of recycled water supply in place of rainwater/solar hot water).

The brief seeks, to the extent feasible, information on:

- Energy savings
- Greenhouse gas abatement
- Capital costs
- Operation and maintenance costs
- Learning and innovation rates
- Avoided network, supply and infrastructure costs for energy and water
- Impact of property features and green suburbs on property values
- Health and wellbeing
- Impact on revenues to Victorian businesses.

1.2 Regulatory Environment

The 6-star standard for dwellings was adopted nationally in May 2010 via the Building Code of Australia (BCA). It was agreed as a national standard and implemented – with variations in timing and with state/territory variations – in all states, generally with 12 months transition time. The Northern Territory is yet to apply the 6-star standard.

General Provisions

BCA2010 and subsequent versions of the Code have a layered hierarchy of objectives and requirements that include objectives, functional statements, performance requirements and building solutions, as shown in Figure 1.

It notes that a building solution will comply with the Code if it satisfies the performance requirements. The options for demonstrating this include:

- Complying with deemed-to-satisfy (DTS) provisions
- Formulating an alternative solution which complies with the performance requirements or which is shown to be at least equivalent to the DTS provisions
- A combination of these two.

The objectives and functional statements are not the performance requirements but may be used as an aid to interpretation.

DTS provisions are detailed in Section 3 of Volume 2 of the Code for Class 1 dwellings (detached and semi-detached houses), and in Section J of Volume 1 for Class 2 dwellings (apartments). They amount to a set of rules and requirements which, if followed, lead to a building solution that is deemed to comply with the performance requirements.

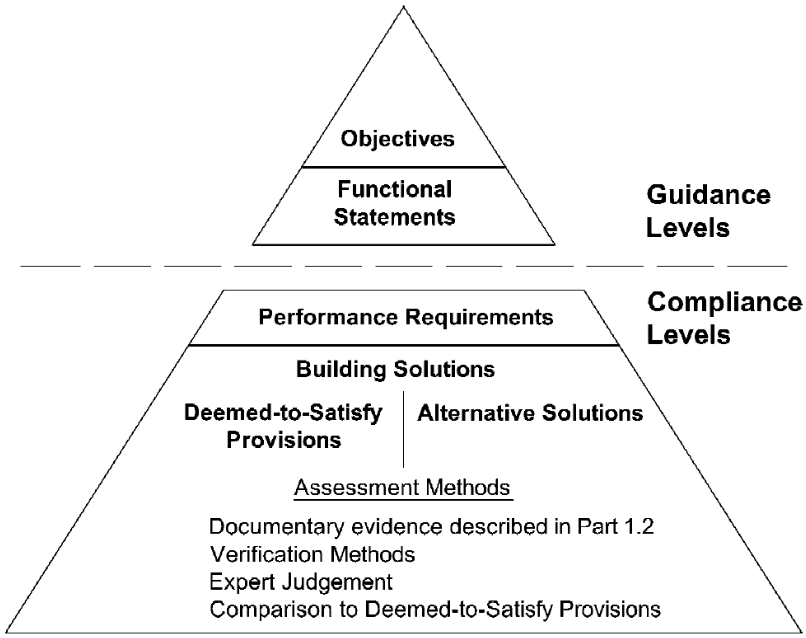

Figure 1: The Building Code of Australia Hierarchy[3]

Alternative solutions are assessed on the basis of one or more assessment methods, including a verification method documented in the Code, other verification methods deemed acceptable by a building authority, comparison with DTS provisions and expert judgement.

Part 2.6 of Volume 2 of the Code contains the 'energy efficiency' performance requirements, but the objective of this part is 'to reduce greenhouse gas emissions'. The functional statement adds that 'to reduce greenhouse gas emissions, to the degree necessary, a building, including its domestic services, is to be capable of efficiently using energy, and a buildings services for heating are to obtain their energy from a source that has low greenhouse intensity, or that is renewable on-site, or is reclaimed energy'. [4]

However, as noted, these objectives and functional statements are not the performance requirements. The performance requirements are (*inter alia*) that '…a building must have, to the degree necessary, a level of thermal performance to facilitate the efficient use of energy for artificial

[3] ABCB (2010), p. 14.
[4] ABCB, *BCA2010, Housing Provisions, Volume 2*, 2010, p. 72.

heating and cooling appropriate to the function and use of the building, the internal environment, its location…' and other factors. In addition, '…a building's domestic services…must to the degree necessary…have features that facilitate the efficient use of energy…; obtain heating energy from a source that has a greenhouse intensity that does not exceed 100 g CO2-e/MJ of thermal energy load, or a source that is renewable on-site…'. [5]

Strictly, these are the only performance requirements that must be met. However, in practice, compliance with these requirements is demonstrated by the use of verification methods that determine that a proposed building has heating and/or cooling loads that are equal to or less than those calculated to apply to a reference building that complies with DTS requirements in that climate zone. Section V2.6.3 of Volume 2 of the Code (in BCA 2010, but since relocated to Volume 3, Part B) specifies that that hot water system is verified when the annual greenhouse gas intensity of the water heater does not exceed 100 g CO2-e/MJ of thermal energy load, determined in accordance with the relevant Australian Standard (AS/NZS 4234). For the purposes of this calculation, the greenhouse gas emissions intensity of different fuels is specified as:

- Electricity, 272 g CO_2-e/MJ
- LPG, 65 g CO_2-e/MJ
- Natural gas, 61 g CO_2-e/MJ
- Wood or biomass, 4 g CO_2-e/MJ.[6]

The DTS, or 'acceptable construction practices', are set out in Section 3, and the energy efficiency requirements in Part 3.12 of Volume 2 of the Code. The Code notes that there are two options for complying with the relevant DTS provisions (heating and cooling loads, building fabric, glazing, sealing and air movement):

- Option 1 is to achieve the required star rating under the Nationwide House Energy Rating Scheme (NatHERS), and also comply with other requirements including insulation, thermal breakes, compensation for downlights, floor edge insulation and building sealing
- Option 2 is to satisfy all the detailed DTS or 'elemental' provisions.

Part 3.12.0.1 of Volume 2 of the Code specifies that 'to reduce heating or cooling loads, a building must have an energy rating to the Nationwide House Energy Ratings Scheme…of not less than 6 stars…'.[7] This applies to Class 1 dwellings, including houses and 'semi-detached' townhouses. For Class 1 and 2 dwellings, a maximum lamp power density limit of 5W/sqm applies in living areas, while other requirements apply, such as daylight detectors for external lighting.

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[5] Ibid, p. 71.
[6] Australian Building Codes Board, *National Construction Code 2016, Volume 3, Plumbing Code of Australia*, 2016, p. 44 – 45.
[7] ABCB, *BCA2010, Housing Provisions, Volume 2*, 2010, p. 430.

For Class 2 dwellings (units or apartments in a multi-unit dwelling), and also Class 4 dwellings (dwellings in a non-residential building, such as a care-takers' residence), Section J.02 (Volume 1 of the Code) requires that:

- Sole-Occupancy Units (SOU's) of a Class 2 building must collectively achieve an average energy rating of not less than 6 Stars and each individual SOU is to achieve an energy rating of not less than 5-stars (using NatHERS software).

The SOU must also comply with the BCA construction requirements for thermal breaks, insulation and building sealing. The remainder of the building (common areas passageways, plant rooms etc.) and services provisions must comply with the relevant provisions of Section J.[8] Other parts of a Class 2 building (common areas) are required to comply with Section J, Volume 1 of the Code.

Victorian Provisions

In Victoria, the 6-star standard took effect from 1 May 2011, but was implemented differently than in other states. Victoria made use of the state and territory variations provisions to implement requirements that were substantially similar to those in the BCA, but with the addition of references to water conservation in addition to reducing greenhouse gas emissions. The 6-star requirement that is referenced in Part 3.12.0.1, from BCA2011 onwards, does apply in Victoria (noting, as above, that this is only one compliance option). For other states and territories, Part 2.6.2 specifies performance requirements for building services, including hot water systems. For Victoria, the following addition is noted (Part 3.12.0):

> *in the case of a new Class 1 building, having either a rainwater tank connected to all sanitary flushing systems, or a solar water heater system, installed in accordance with the Plumbing Regulations 2008.*

Compliance with the 6-star requirement is generally demonstrated by an energy assessor preparing a rating using a NatHERS accredited software tool (FirstRate5, BERS Pro or AccuRate). The Victorian Building Authority (VBA) recommends but does not require that the assessments are undertaken by accredited Thermal Performance Assessors.[9] Regulation 25 of the Building Regulations 2018 requires that the building surveyor is provided with detailed designs and evidence of compliance with energy performance requirements, *inter alia*, before a building permit may be issued.

For alterations and extensions to 5- or 6-star dwellings, the previous energy rating must be maintained. Additions and extensions may demonstrate compliance via DTS or NatHERS methods, but if the NatHERS method is used, the whole dwelling including the addition must be assessed. Where alterations completed within a 3-year period represent more than 50% of the volume of the original building, the entire building must comply with the *current* energy performance standard. Where an extension or addition represents less than 25% of the floor area of the existing building, and is less than 1000 sqm, the building surveyor may approve 'partial compliance'.

[8] Victorian Building Authority, *Practice Note 55-2018*, *Residential Sustainability Measures*, p. 2.
[9] http://www.vba.vic.gov.au/consumers/energy-efficiency-performance-requirements

The VBA's Practice Note 55-2018 (and its predecessors) further specify, for new Class 1 dwellings only:

- A rainwater tank (minimum capacity of 2000 litres), drawing on a minimum of 50 sqm of roof area, connected to all toilets in the building for the purpose of sanitary flushing; or
- A solar water heater system installed in accordance with the Plumbing Regulations 2008 (the plumbing regulations).

Where a solar water heater is selected, the plumbing regulations require that gas-boosted systems are used in areas where reticulated gas is available. Heat pump water heaters may only be selected in areas not supplied by the gas network or if they use non-grid-sourced electricity. Where a rainwater tank or a solar water heater system is installed, the RBS must see a copy of the plumber's compliance certificate issued under section 221ZH of the Act before an occupancy permit can be issued.[10]

These arrangements are implemented in Victoria as a variation to the National Construction Code, replacing Part 3.12.5.0 (building services) in Volume 2 of BCA 2010 (Part 3.12.0a in Volume 2 of NCC 2016). They were first implemented in 2005, and our analysis of them therefore begins in FY2006.

1.3 National Policy Context

The 6-star standard has been a long-lived standard, when compared to earlier standards. In 2015, the Council of Australian Governments (COAG) Energy Council agreed a National Energy Productivity Plan and Work Plan. This notes that:

> *The Council agrees that given the longevity of buildings, which will stand in many cases beyond the middle of the century, and the extent of industry developments since the last significant change to minimum residential and commercial building energy efficiency standards in the National Construction Code in 2010, there are very likely strong productivity and emissions reductions benefits in further revising energy efficiency requirements in building codes for both residential and commercial buildings.*

The COAG Energy Council noted that there was a need to 'gather more evidence around the effectiveness of existing Codes and standards, particularly for residential buildings. The Council will engage in an intensive research programme to inform development of updated building efficiency requirements.'[11]

The Work Plan refers to a process to consider changes to the 2019 edition of the Code, but it is understood that the question of any changes to residential building performance requirements will be considered in the context of the next 3-year regulatory cycle, for 2022. New energy performance requirements for non-residential buildings will be included in NCC2019.

[10] VBA (2018), p. 4.
[11] COAG Energy Council, *National Energy Productivity Plan: Work Plan*, 2015, p. 20.

2. Evaluation Methodology

2.1 Overview

2.1.1 Introduction

The core requirements of a policy evaluation are:

1. To determine, so far as it possible, what happened in response to the policy's introduction. This includes not only the intended changes, but any evidence of unintended or consequential changes;
2. To assess the extent to which the outcomes observed are attributable to the policy in question, as compared to other policies or market factors;
3. To analyse the extent which the policy was cost-effective.

In this context, it should be noted that it is not feasible to have full and complete knowledge of what actually happened in response to any policy, but particularly one such as this that has been long-lived and which has affected hundreds of thousands of individual dwellings over time.

Further, there is a cost to the taxpayer associated with assembling data and evidence about policy impacts, and there could also be costs to the regulated parties – for example, time-costs associated with surveys or other data-gathering techniques. Therefore, pragmatic judgements must be made about the extent to which is it necessary and cost-effective to seek additional information and evidence.

Further, key data elements relevant to this evaluation are considered either private, sensitive, commercial-in-confidence, or all three. In particular, the individual energy consumption patterns of specific households, and the costs actually incurred by homeowners and builders over time, are not directly observable. Rather, they must be inferred from available sources (documented below).

The large number of dwellings affected, over a long period of time, means that statistical means can be used to represent the overall outcomes, without needing direct recourse to information regarding every dwelling. At the same, the passage of time creates challenges in distinguishing policy impacts from impacts and changes that may have occurred in any case, even without the measure in question. For example, the Code variation incentivises the uptake of solar hot water heaters, but solar hot water uptake has increased in most states and territories. However, we note that gas-boosted solar system uptake in Victoria is high compared to other states.

Similarly, other policies and measures, and market factors, have impacted on star rating outcomes and on the uptake of solar hot water systems in Victoria over the period in question. In particular, several Councils call for above-mandatory-minimum sustainability performance.[12] The impact of

[12] At least Melbourne, Yarra, Whitehorse, Stonnington, Moreland, Banyule and Port Phillip apply Environmentally Efficient Design or Environmentally Sustainable Design policies that encourage above-

these provisions is effectively entangled with the impact of the policies in question in at least some data sets. Therefore, an assessment must be made about the extent to which observed outcomes are attributable to the policy in question or to other effects.

Our overall approach to this task is as follows:

1. To gather and review the available data and evidence from multiple sources
2. To conduct an extensive literature review of relevant studies that illuminate the research scope
3. To conduct a series of structured interviews with up to 30 key stakeholders in the residential building sector in Victoria
4. To conduct formal social benefit cost analysis, informed by the data captured in the above steps, for each element of the policy and overall
5. To conduct thermal performance modelling and cost assessment, to validate other data sources regarding typical design specifications and costs
6. To draw overall conclusions.

Further information on the methodology applied in each of these steps is provided below.

2.2 Data Capture

This evaluation has involved extensive data capture and analysis. Key sources are noted below, and also referenced in appropriate places in the body of the report. Note that substantive studies (as compared to data sources) are reviewed in the Literature Review in Chapter 3.

2.2.1 Energy-Related Data

Key data sources used for analysis of energy provisions (6-star) include:

- For building stock composition, distribution, growth and turnover:
  - Australian Bureau of Statistics (ABS) Census data, 2011 and 2016:
    - 2011 Census of Population and Housing, Time Series Profile (Catalogue number 2003.0)
    - 2016 Census of Population and Housing, Time Series Profile (Catalogue number 2003.0)
    - 2071.0 Census of Population and Housing: Reflecting Australia - Stories from the Census, 2016 - Apartment Living
  - ABS Building Activity data

minimum-standard performance through planning schemes, including in energy performance and stormwater management.

- ABS, 8752.0 Building Activity, Australia, TABLE 42. Value of Building Work by Sector, Victoria: Original
- ABS, 8752.0 Building Activity, Australia, TABLE 38. Number of Dwelling Unit Completions by Sector, States and Territories
- ABS, 8752.0 Building Activity, Australia, TABLE 39. Number of Dwelling Unit Completions by Sector, States and Territories: Original
- ABS, Customised Report, Average Floor Area

- Building permit data supplied by the VBA
- Built Environment Sustainability Scorecard (BESS) data (provided by the Council Alliance for a Sustainable Built Environment (CASBE) on a confidential and deidentified basis)
- Victorian Valuer-Generals' property valuation data (to 2016)

- For building energy consumption/ratings:
  - CSIRO NatHERS portal ratings data (provided on a confidential and deidentified basis)
  - BESS data, as noted above
  - Office of the Chief Economist, *Australian Energy Statistics*, Table F.[13]

2.2.2 Solar Hot Water-Related Data

Key data sources for the uptake of solar hot water systems include:

- Building permit data supplied by the VBA (noting whether rainwater tanks or solar hot water heaters were specified in Class 1 building permits)
- BESS data, as noted above.

2.2.3 General Data

Other data inputs to the study include:

- ABS, 6401.0 Consumer Price Index, Australia, TABLE 5. CPI: Groups, Index Numbers by Capital City
- VEEC pricing data (2013 – 2016) from TFW Green

[13] DELWP notes that there are differences between Australian Energy Statistics and the Residential Baseline Study with respect to Victorian residential gas consumption. The latter shows that household-level gas consumption started to decline from the mid-2000s in Victoria, whereas the former indicates continued increases in gas consumption. DELWP notes that the Residential Baseline Study data accords better with data from Victorian gas distributors.

- ABS, 6427.0 Producer Price Indexes, Australia, Table 18. Input to the House construction industry, six state capital cities, weighted average and city, index numbers and percentage changes
- Shadow carbon price assumptions, provided by the Department of Environment, Land, Water and Planning (DELWP)
- *Residential Baseline Study* (2015) data tables.

2.2.4 Data Limitations

Overview

There are significant limitations on the availability of data to support an evaluation of these policy measures. Specific limitations and data issues are discussed in context in Chapter 6: this section provides a general overview and analysis of the significance of these issues, by policy element.

The most significant limitation is the absence of measured energy consumption data (by fuel) for the 6-star and 5-star cohorts, or at least data on their hot water, space conditioning and lighting energy consumption, as this is what is targeted by the 6-star policy. We therefore rely primarily on NatHERS ratings data as the key indicator of energy performance. The implied assumptions include:

1. that compliance with 6-star is comparable to compliance with 5-star – that is, there is nothing peculiar about the degree of compliance with 6-star as compared to earlier energy performance standards
2. factors such as thermostat set-points, occupancy levels and zoning behaviours are comparable between the 6-star dwelling cohort and those complying with the previous 5-star standard.

While there could be further investigation of these assumptions (and, as noted, there are compliance audits underway at the time of writing), we believe these are reasonable assumptions to make. Some stakeholders consulted raised issues regarding NatHERS and its application, including factors such as thermostat set-points in ratings mode that are believed to be too high in summer, and therefore to under-estimate summer energy consumption in the real world. While these are important issues, and worthy of attention by the NatHERS Administrator, they are not unique to the 6-star standard and therefore do not impact on our quantitative analysis. Similarly, while there are concerns held about the degree of compliance with energy performance standards in the construction industry, regardless of the state or building class,[14] we have no reason to believe this degree is different for 6-star as compared to 5-star dwellings, and we would not attribute the degree of non-compliance as causally linked or inherent to the 6-star performance standard.

[14] See, for example, pitt&sherry and Swinburne University, *National Energy Efficient Buildings Project: Phase 1 Report*, December 2014.

Construction activity

The number of dwellings built to the 6-star standard each year by dwelling type is not known exactly. The number of detached houses completed annually (or quarterly) is available from the ABS, but apartments and townhouses are mixed together in a category known as 'other residential'. The spatial resolution of this data is whole-of-state. Similarly, the average floor area of new completions is available (for purchase) from the ABS, but only for 'houses' and 'other residential, and with limited spatial resolution ('greater Melbourne' and 'rest of state'). This activity data is not available by climate zone, local government area (LGA) or post code.

Dwelling permit data from VBA is available by LGA, but only for Class 1A (houses and townhouses combined). Another 'activity' data source is the Victorian Valuer-Generals' data. This provides housing counts by construction year, current to end 2015. In principle, these counts should agree with the ABS completions data. However, a comparison of results over the 2010 to 2015 period showed that the VG counts averaged 92% of the ABS counts and ranged between 88% and 106% from year to year. Also, while VG housing stock data was available by LGA, the annual additions to the stock were not. This means that the spatial distribution of the new building activity, by LGA or climate zone, is not indicated.

Renovations, additions, extensions, conversions and demolitions are poorly resolved. There is no direct source that indicates the demolition rate. As discussed in Chapter 6, the VG data appears to significantly under-estimate renovation activity, as much of this activity would not be reported to the VG's office. ABS completions data indicates the total number of alterations, additions and conversions (from one building class to another), but not the split between these three activity types from any information about the nature of the conversion (to/from which class, for example).

As also discussed in Chapter 6, there is broad agreement between ABS Census and VG data about the total size of the dwelling stock in Victoria, but poor agreement on the composition of the stock by dwelling type. Given the nature and purpose of both data collections, accurate categorisation of dwellings by their NCC Class should not be expected.

We note that, for 2016 onwards, NatHERS ratings counts are available by climate zone. However, not all new dwellings are rated under NatHERS. That said, we report below that it appears that the majority of dwellings are rated, and so the spatial distribution of NatHERS ratings is likely to be a good proxy for the spatial distribution of residential construction activity. Unfortunately, the NatHERS ratings data does not separate houses from townhouses.

Overall, the various data sources available enable a reasonable picture to be drawn of housing construction activity over time in Victoria. However, the distribution of this activity by climate zone or LGA and by dwelling is not well resolved, while the rate of activity in demolitions, additions, alterations and conversions is poorly resolved.

Energy consumption

The actual energy consumption of the cohort of dwellings built to the 6-star standard in Victoria is not known. This is also true for the 5-star cohort. Thus, the simple expedient of comparing the energy consumption of the two cohorts, to determine whether there are material differences, is not available. Fundamentally this is because there is no reporting requirement that resolves specific housing cohorts. Electricity distributors report total electricity consumption by tariff class (including residential) to the Australian Energy Regulator annually, but this is not broken down by new/existing houses, age of house, by LGA or climate zone, or by other characteristic that would enable the consumption data to be associated with the newly constructed stock. The Australian Energy Statistics reports total residential consumption by fuel source, but only for the whole of the state. In the CSIRO evaluation of the 5-star standard nationally, this limitation was tacked by recruiting and monitoring the consumption of close to 600 houses in three states for a year.[15] Such strategies are extremely resource- and time-intensive and were not available for this study. As a result, in this study we impute the average energy consumption of the 6-star cohorts from the average NatHERS ratings data supplied by CSIRO.

The actual annual electricity and gas consumption of every dwelling in Victoria is known to the relevant energy distributors. However, these businesses are required only to report highly aggregated totals, as noted above. In principle, it should be feasible to collect and analyse the disaggregated data under suitable confidentiality and privacy constraints. This would require suitable agreements, or otherwise regulations, to be put in place by the Victorian government. For policy analysis purposes, data aggregated to the post code or even LGA level – but layered into meaningful cohorts – would suffice, and this should largely nullify privacy and confidentiality concerns. The CSIRO's *End Use Data Model* (EUDM) project is making some progress towards this end, at least for electricity consumption data.[16]

In addition to the annual energy consumption of 5 and 6-star houses, an evaluation of the 6-star standard (and hot water regulations) requires an understanding of the type of hot water and space conditioning equipment installed in each housing cohort, and also of the fuel mix of at least hot water and space conditioning equipment. This is because, in the absence of information about the direct energy consumption of the 6-star (and 5-star) cohort, and the consequent need to rely on NatHERS ratings data, information on the space conditioning equipment type and fuel mix is needed to estimate fuel consumption.[17] The fuel mix also determines the greenhouse gas emissions and associated costs and benefits. The fuel mix also is one factor affecting energy costs for consumers.

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[15] CSIRO, *The Evaluation of the 5-Star Energy Efficiency Standard for Residential Buildings*, December 2013.

[16] https://www.csiro.au/en/Research/EF/Areas/Electricity-grids-and-systems/Economic-modelling/Energy-Use-Data-Model, viewed 2/1/2019.

[17] A NatHERS star rating refers to a unique annual average thermal load on dwellings by climate zone. To convert this to annual energy consumption requires knowledge of the type of space conditioning equipment and its energy efficiency, at a minimum. As discussed in Chapter 6, ideally we would also know something about the actual occupancy conditions for each cohort, thermostat settings and occupants behaviours, as

Again, data on the hot water and space conditioning technology and fuel mix, specific to the 5-star and 6-star housing cohorts, is not generally available. The best data source for space conditioning equipment that was available to this study was the BESS data set, as this provides data on at least the primary heating and cooling equipment types installed in dwellings covered by that set, which includes over 56,000 dwellings over the 2016 – 2018 period. However, this is only a portion of the period covered by 6-star, and also the distribution of dwellings in the BESS data set is skewed towards apartments (69% of the sample) and townhouses (28% of the sample), with only 1,000 single houses and nearly 600 Class 4 dwellings (such as caretakers' residences). In the absence of other data sources, this source is used to indicate the typical space conditioning mix being installed in new dwellings in Victoria.

A limitation in the BESS data as made available to the study is that the space conditioning and hot water mix was only revealed by project or development. On average, each project or development in this data set contains around 3.3 dwellings. It is likely that similar data by dwelling would be held by BESS. While data is available from BESS regarding hot water system types, this data does not appear to include solar hot water options and therefore is not directly useful to this study. Ideally, both electric- and gas-boosted solar options would be added to the relevant data questionnaires. We note in Chapter 6 that the Department previously was able to purchase data on attributes of new housing from a private source (BIS Shrapnel), but these data publications have been discontinued.

Overall, the lack of direct observation of household energy use by fuel (and end use) is unfortunate. It is, however, consistent with the steady reduction in the availability of this kind of statistical information that has been in evidence for at least the last decade. The ABS, for example, published a series known as *Environmental Issues: Energy Use and Conservation* approximately every three years, at least from 2008 – 2014.[18] This provided important insights, for example into hot water systems by fuel, main heating sources, main system of air conditioning, the incidence of insulation, and basic appliance information. However, the 2014 edition is the latest and, according to our understanding, the last expected to be produced in this series. A one-off *Household Energy Consumption Survey, 2012* is of limited utility due to the highly aggregated nature of the data presented, the lack of timeseries data and other limitations. More generally, the increasing complexity and fragmentation of energy markets in Australia has not been matched by an increased effort to ensure that an adequate statistical picture of energy consumption and related drivers is available. This means that the availability and quality of data for government policy analysis and development purposes is generally declining. In many ways this is ironic, as the energy market has at the same time become much more data-rich – in Victoria in particular, smart meters are widespread and capture data on electricity consumption at 30-minute intervals. As noted, CSIRO is

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these also affect energy consumption. As these, too, are not known, we apply the default values for these factors that are embedded in the NatHERS software protocol, ratings mode.

18 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4602.0.55.001Main+Features1Mar%202014?OpenDocument, viewed 2/1/2019.

attempting to capture, analyse and publish (in confidentialised form) at some energy consumption data via its EUDM project, but this is at an early stage.

Lighting

The type and amount of lighting installed in 6-star and 5-star houses in Victoria is not known. Given that the 6-star standard includes lighting power density requirements for residential buildings, the lack of data to confirm the extent to which these requirements are being met is of concern. The Department of Environment, Land, Water and Parks and the Victorian Building Authority are currently conducting audits of a sample of new 6-star dwellings in Victoria, and this is likely to provide useful insights. However, this project was not sufficiently far advanced to provide data inputs into the current evaluation.

Solar hot water

As discussed in greater detail in Sections 2.6 and Chapter 6 below, the VBA collects data on the frequency with this new Class 1 dwellings in Victoria select solar hot water (SHW), or instead a rainwater tank, under plumbing regulations, noting that between 20% - 30% of choices are not reported in this source. However, the overall mix of hot water choices by type and fuel is not documented – except, as noted above, in the BESS data since 2016, for some LGAs. This complicates the process over determining the likely extent of energy savings attributable to the SHW provisions. In any case, an evaluation seeks to establish the impact of a policy intervention relative to a 'without policy' counter-factual case. Given that the plumbing regulations have been in place since 2005, it is increasingly difficult to be confident about the mix of hot water systems that would have been expected in 2018, for example, under a 'without policy' counterfactual scenario.

The extent of energy (and energy cost) savings associated with the SHW element is also affected by the annual energy consumption for households associated with each hot water technology. As noted above, the technology mix in new houses is not well documented outside BESS, but, in addition, the energy savings will also be affected by the hot water consumption of households and the energy consumption required of different hot water technologies to supply these hot water consumption needs. At a micro level, even hot water draw-off patterns matter, because even for a given level of annual hot water use, these will affect the extent of standing losses (heat losses through pipes and hot water storage units). As discussed in more detail in Chapter 6, different data sources offer different observations about relevant values.

2.3 Literature Review

A formal review of literature has been conducted, documenting and briefly summarising key references pertaining to the energy and water performance requirements. The results are presented in Appendix 1 and briefly summarised in Chapter 3 below.

2.4 Consultation

The brief for this project calls for consideration of how the 6-star standard has impacted on building industry practices. Considerations include:

- Design responses, such as improvements to orientation and form vs incremental increases to insulation and glazing specifications;
- Market transformation, such as the degree to which solar water heater requirements have impacted on industry; the rate of adoption of double and low-e glazing and other innovations;
- Occurrence of new dwellings that exceed the minimum standard;
- Prevalence of non-NatHERS solutions (e.g. the use of deemed-to-satisfy in preference to a NatHERS rating, verification methods using a reference building);
- Prevalence of dispensations and non-compliance (noting that DELWP is also delivering another project dealing with as-built compliance).

While quantitative data sources provide insights in some of these areas, others – such as design responses, market transformation impacts and the responses of particular market segments (insulation, glazing, additions/extensions vs new build, Class 2 vs Class 1) – are perhaps best illustrated by direct engagement with building industry stakeholders.

Chapter 4 summarises stakeholder comments, while detailed responses are included in Appendix D. We note that some comments were also offered with respect to the rainwater tank option under the Code variation, and these are recorded for completeness.

2.5 Impact and Benefit Cost Analysis Method – Energy Requirements

2.5.1 Housing Stock Composition and Evolution

Consistent with the overall requirement to map 'what happened', we constructed a stock turnover model that captures information on the number and floor area of new dwellings added to the stock over the FY2012 – FY2019 period, and also on the number and floor area of extensions and additions. This represents the period over which 6-star impacts are evaluated. For the solar hot water provisions, which commenced in July 2005, we also examine Class 1 completion trends back to FY2006, and policy impacts from that time forward to the end of the current financial year, FY2019.

This required reconciling conflicting observations from different sources and, ultimately, making judgements about the best data sources to utilise for this study, and how to make best use of the information content of different sources. Where sources differ on significant values, these differences are noted in Chapter 4 below.

2.5.2 Energy Performance Outcomes

The next key element in assessing the outcomes of the 6-star standard is to determine, so far as possible, what the actual outcomes were, as compared to the 6-star expectation.

It is important to note that is not necessary to capture data on the actual energy use of all 513,000 dwellings built to this standard in order to address this question. The 6-star standard does not regulate the whole energy performance or consumption of dwellings. Nor does it regulate the occupancy pattern of dwellings, the density of plug-in appliances, energy use behaviours, nor the choice of space conditioning equipment, nor less the actual climate from time to time – yet all these factors have a large influence on the actual energy consumption of dwellings, independently of its star rating. Rather, and as set out in Section 1.2, the 6-star standard seeks to regulate the annual thermal load of the thermal envelope of dwellings. For the most part, this is indicated by the star rating. Two qualifiers on this observation are:

1. The extent to which dwellings 'as built' comply with the 'as-designed' rating and with the 6-star standard
2. The accuracy of the star rating.

On the first question, the Victorian Building Authority is currently undertaking a large number of audits with the aim of verifying the extent of as-built compliance *inter alia*. On the second question, a national study conducted in 2014 gave some cause for concern.[19] A sample of 314 energy assessors (out of an estimated total of 1816 assessors) agreed to participate in an evaluation found that only 37% of assessments conducted for the study were within 0.25-stars of the correct rating, while 64% of assessors had an error margin greater than this. While the results of this study were not differentiated by State, Victoria contributed the largest share of assessors (34.1%) that participated in the study.[20]

Our key data source on Victorian dwelling ratings is the CSIRO NatHERS Portal data, and we acknowledge with gratitude CSIRO's willingness to share this data on a de-identified basis. We are also grateful for data provided by the Built Environment Sustainability Scorecard (BESS) Governance Board representing outcomes measured by BESS over the period from mid-2016 to mid-2018. The results, drawing on both data sources, are summarised in Chapter 4.

We construct three scenarios that work progressively towards the energy savings attributable to the 6-star standard alone. Scenario 1 is a reference scenario that estimates energy savings if all of the floor area built to Code since May 2011 were at exactly 6-star rather than 5-star. Scenario 2 then applies the data from the NatHERS Portal on actually realised star ratings, to re-estimate the energy savings over time. Finally, Scenario 3 reallocates a portion of the above-6-star ratings to the effect of Sustainable Design Assessment in the Planning Process (SDAPP) schemes run by certain Councils in Victoria, that generally call for an additional 0.5-star rating above the mandatory

[19] Floyd Energy, *NatHERS Benchmark Study*, February 2014.
[20] Ibid, p. 48.

minimum. In effect, the disproportionate number of 6.5-star ratings, particularly for Class 2 dwellings, is attributed to these schemes rather than to the 6-star standard.

The analysis quantifies the *change* in the annual thermal load allowance for each climate zone in Victoria embodied in 6-star relative to the previous 5-star standard, both for new dwellings and for alterations and additions. This approach is taken because it abstracts from questions such as the degree of compliance with the Code: if the degree of compliance is the same for 6-star as it was for 5-star, then the change in annual thermal load from 5-star to 6-star will provide an accurate measure of the impact of the 6-star standard. We note that DELWP and the Victorian Building Authority are currently undertaking a project to examine the extent of compliance/non-compliance with the 6-star energy performance requirement.

Similarly, there is a debate about the extent to which behavioural and occupancy assumptions implicit in the NatHERS software protocol are reflective of actual household behaviours and occupancy. However, focusing on the *change* in annual thermal allowances again allows the analysis to abstract from these questions. The implicit assumption is that there is no systemic change in these behaviours and occupancy patterns that are attributable to the 6-star standard. We believe this is a reasonable assumption.

Lighting

The analysis of the lighting measures is constrained by a lack of detailed annual data on the lighting solutions installed in new houses before and after the 6-star standard. Relatedly, there is a great deal of choice of lighting systems available to consumers, including a wide range of lighting technologies and efficiencies. A detailed study from 2007 by George Wilkenfeld and Associates (GWA) provides a strong picture of the pre-6-star environment in Victoria, and we also use data from BIS Shrapnel (2009), which also relates to 2007.[21,22] On the issue of lighting diversity and efficiency, GWA note that "The most common lighting options can vary in their use of energy per area by a factor of more than 10 to 1" (p. 66).

As a response to the lighting diversity problem, we follow GWA's solution of describing a set of common 'lighting solutions' (developed in consultation with a major lighting provider) and estimating how the mix of these solutions would have evolved with/without the 6-star standard. The lighting solutions include:

- A 'Basic' design, using incandescent lamps, typically used in about 60% of houses and 70% of apartments (according to Beacon Lighting)
- A 'Premium' design, with a high proportion of LV halogens – this is typically the scheme shown in display homes, but is used in only about a third of built houses and a quarter of apartments

[21] George Wilkenfeld and Associates, *Options to reduce greenhouse gas emissions from new homes in Victoria through the building approval process*, April 2007.
[22] BIS Shrapnel, *Lighting Installed in New Dwellings*, March 2009.

- An ‘efficient’, version of the ‘Premium’ scheme, in which LV halogens are replaced with 230V ‘Megaman’ micro-CFLs, and bayonet-mounted incandescents with CFLs. This scheme is used in about 4% of houses and 3% of apartments.
- GWA developed a fourth lighting scheme: an ‘all-CFL’ version of the Basic, which was applied to 3% of houses and 2% of apartments.

Note that since LEDs were not commonly in use in 2007, we developed a ‘100% LED’ version of the ‘all CFL’ solution (with the same number of lamps as the all CFL solution). Also, recognising that LEDs were transitioned into new housing over time, a hybrid ‘CFL+LED’, with an assume 50/50 mix of each. Key assumptions by GWA include an average lamp use of 1.6 hours/day, and we assume that 6W LED lamps are used.

It should be recalled that the COAG initiated a phase-out of most incandescent (but not halogen incandescent) lamps from 2009, so this is modelled as the BAU case. Another notable factor is that both GWA and BIS Shrapnel note a significant share of halogen lighting around this time, particularly at the premium end of the housing market.

2.5.3 Treatment of Time

The savings and indeed costs examined in this evaluation occur between 2005 and 2019. To convert them into values that are easily interpreted relative to prices and costs in today’s economy, it is necessary to follow a multi-step process, depending upon the original value observation:

1. Capture past prices/costs (eg, electricity and gas prices or incremental construction costs), which are often expressed in nominal dollars, or ‘dollars of the day’;
2. Convert these to ‘real’ or constant dollars by deflating past values by an appropriate deflator that represents how the prices of electricity gas have moved over time relative to general prices[23]
3. Discounting savings values over time by a real discount rate that reflects the social rate of time preference (4% real)
4. Where ‘present values’ are summed for a point in the past, these values then need to be adjusted back to today’s FY2019 values.

2.5.4 Value of Energy Savings

For both electricity prices, we sourced real prices indices that already account for the impact of inflation over time. For electricity, we have used the real price index for Victoria from Jacobs’ *Retail Electricity Price and Projections*, June 2017. To base this index series in appropriate *recent* prices, we reviewed the numerous reports generated for the 2017 *Independent Review into the Electricity*

[23] The term ‘deflator’ is used in economics, but in fact past values, observed in dollars of the day, and almost invariably *inflated*, relative to today’s values, to convert them into ‘real’ or inflation-adjusted values. This recognises that inflation over time has eroded the value a dollar. Applying the logic in reverse, and in the presence of inflation, the real value of a dollar (earned or spent) in the past is higher than today’s value.

and Gas Retail Markets in Victoria. In particular, analysis by Carbon Markets & Energy (CME)[24], found that the average price actually paid by Victorian residential customers in the period to mid-2017 was $0.355 $/kWh incl. GST. The Jacobs index is therefore applied to this value to generate an historical electricity price history for the residential sector in real or inflation-adjusted dollars. The Jacobs' index is projected to 2037, and we assume constant real prices thereafter – see Figure 2. It is necessary to estimate future prices, even for a retrospective evaluation, in order to value the energy savings and avoided network costs over the full economic life of the dwellings, which we assume to be 40 years.[25]

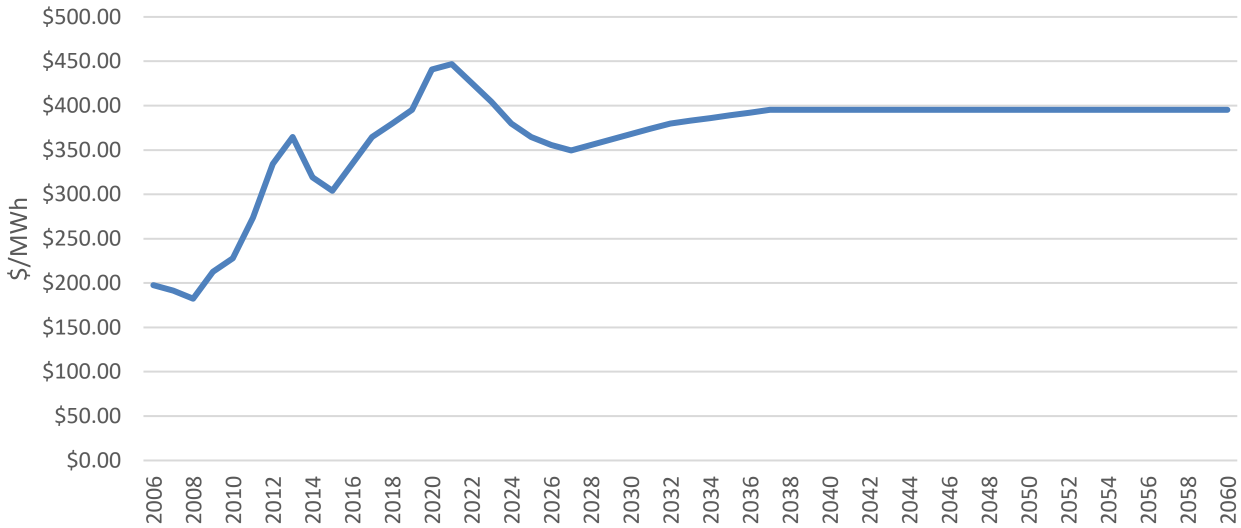

Figure 2: Real Residential Electricity Price History and Projections, Victoria

Gas prices are constructed in a similar way, informed by Oakley Greenwood's contribution to the Independent Review, in addition to a CME study on actual gas pricing and consumption.[26,27] CME found an average price of $26.58/GJ in the residential market in early-mid 2017, and this value is applied to Oakely Greenwood's real price index for the historical period. As this series is not forecast into the future, we assume that gas prices will follow a similar path in relative terms to electricity. While this is not certain, there is competition between the two fuels in the residential market – see Figure 3.

[24] CME, *The retail electricity market for households and small businesses in Victoria*, July 2017.
[25] This assumption is used by the Australian Building Codes Board and may be shorter than the actual average life of a residential building. However, the effect of discounting is such that impacts that occur more than 40 years into the future have little impact on the analysis. For example, a value of $100 that occurs 41 years into the future has a present value of $18.75 at a real discount rate of 4%. The 40 year economic life may make the analysis slightly more conservative than if a longer economic life were assumed, but the results will not be sensitive to changes in this assumption.
[26] Oakley Greenwood, *Gas Price Trends Review 2017, Version 2.1*, March 2018.
[27] CME, *Victorian retail gas market for residential and small business customers*, May 2017.

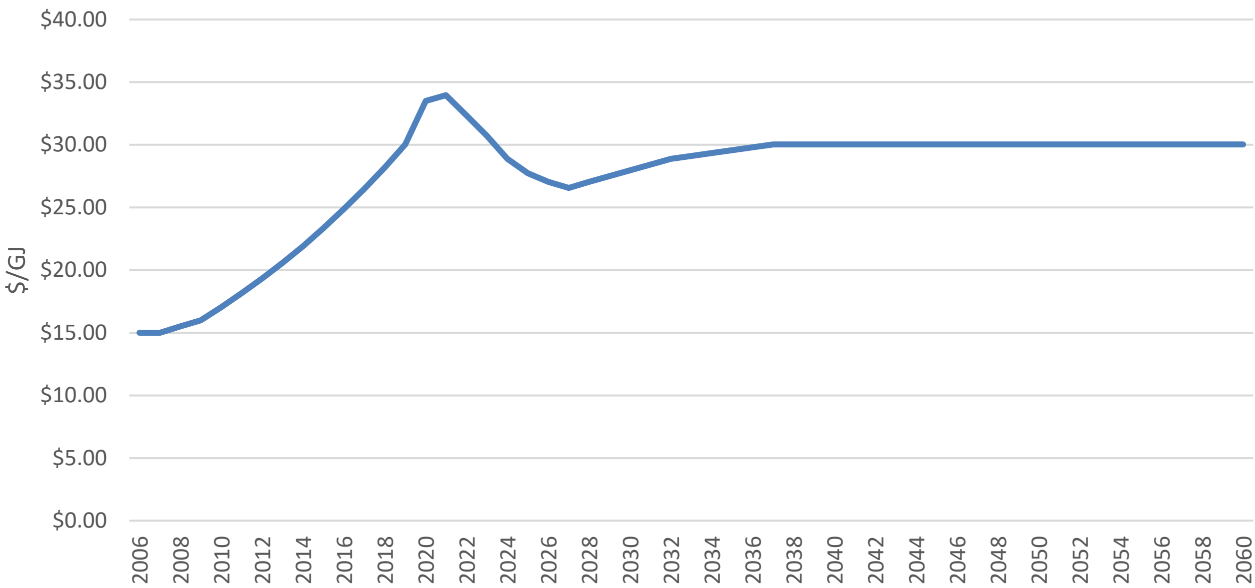

Figure 3: Real Residential Gas Price History and Projections, Victoria

2.5.5 Shadow Carbon Prices

As Australia does not currently have a carbon pricing scheme yet is incurring the social costs associated with climate change, there is an unpriced external benefit associated with reducing greenhouse gas emissions. Ideally, this value would be related to the avoided future climate-related damage costs. These may be very large, but they are also extremely difficult to quantify and attribute, given the global nature of the greenhouse effect. A conventional solution is to apply 'shadow' carbon prices that are intended to represent the social value of avoided emissions. The following shadow carbon price series was supplied by the Department in order to increase comparability of the results of this and other studies that use shadow carbon prices – see Table 4. The Central value is used as the default in the results reported in Chapter 4.

$/t CO2-e	Lower	Central	Upper
2018	12	19	57
2019	13	23	61
2020	14	28	65
2025	20	49	86
2030	25	71	106
2035	42	107	148
2040	59	142	189
2045	76	178	231
2050	92	213	272

Table 4: Shadow Carbon Prices (Selected Years)

DEWLP notes that the Central trajectory started at the median of carbon pricing initiatives as at 1 December 2017 from the World Bank's Carbon Pricing Dashboard, which was USD15.08. This was converted to AUD using the average monthly exchange rate for January 2018, which resulted in a value of $19 AUD for 2018. The post-2030 values for the central trajectory are the median carbon prices contained in IPCC Fifth Assessment Report scenarios that are consistent with keeping atmospheric concentrations of carbon dioxide equivalent to between 480 ppm – 530 ppm. Values were converted into Australian dollars for the relevant year using an average annual exchange rate, and then escalated to 2016 values using an Australian GDP deflator. Conversion indices used are from the World Bank's World Development Indicators published in the Bank's online databank.

The values for the lower trajectory are the median carbon prices contained in IPCC Fifth Assessment Report scenarios consistent with keeping atmospheric concentrations of carbon dioxide equivalent to 580 ppm – 650 ppm, converted to Australian dollars using a similar method as above. The upper trajectory uses the same source but draws on the median of carbon prices from scenarios considered likely (a probability greater than 66%) to keep warming below 2 degrees – consistent with atmospheric concentrations of carbon dioxide equivalent to 430 ppm – 480 ppm.

Since a portion of the energy saved due to 6-star is electricity, and these savings will persist for the expected economic lives of the dwellings affected, it is necessary to estimate the degree to which these electricity savings will reduce future greenhouse gas emissions in Victoria. Historical emissions intensity values are sourced from the National Greenhouse Accounts Factors Workbook[28], and future values from the work conducted by CSIRO and Energy Network Australia. These parties undertook a multi-year process of research and extensive stakeholder engagement to produce a 'roadmap' that describes the expected future evolution of the electricity network (and wider system) by state over the period to 2050.[29] The resulting emissions intensity projection are shown in Figure 4. We note that the assumption of a significant reduction in the greenhouse gas intensity

[28] Australian Government Department of the Environment and Energy, *National Greenhouse Accounts Factors*, July 2017.

[29] CSIRO/Energy Networks Australia, *Electricity Network Transformation Roadmap: Final Report*, April 2017.

of electricity supply over time means that that future quantity, and hence value, of avoided gas emissions due to 6-star will be *less* than would otherwise have been the case. Alternatively, if the emissions intensity of electricity consumption in Victoria is higher than shown below, then the value of the emissions avoided by 6-star will be higher than assumed in this study.

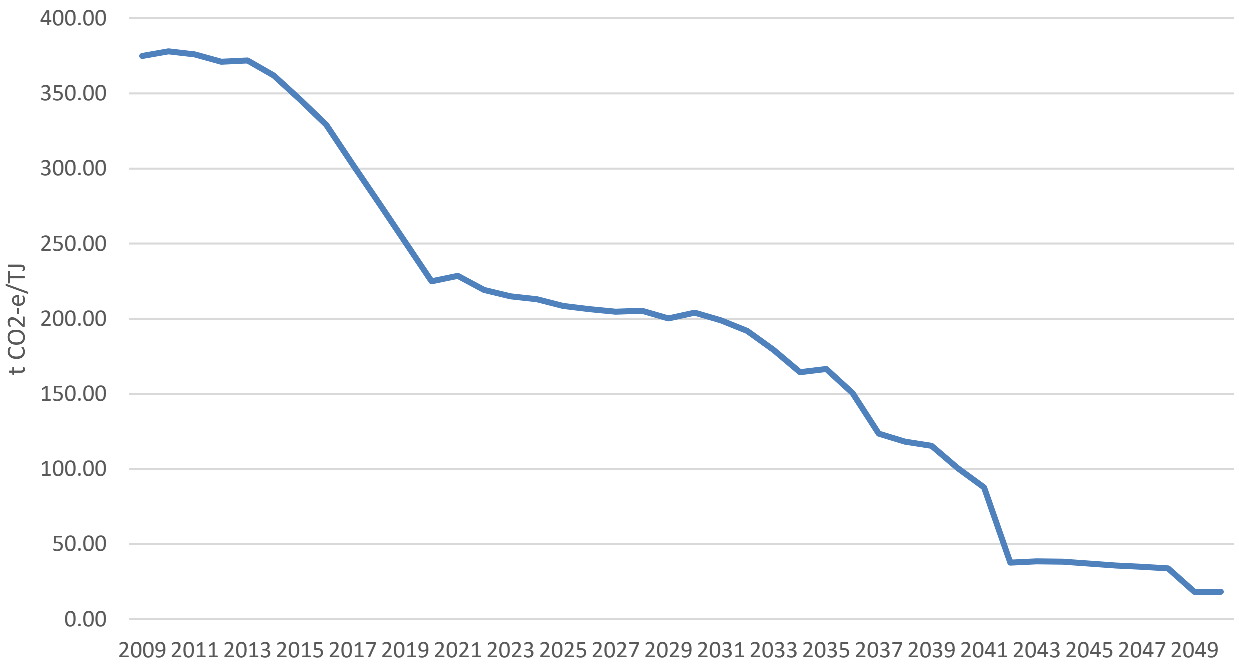

Figure 4: Historical and Projected Future Greenhouse Gas Intensity of Electricity Consumption, Victoria

2.5.6 Avoided Electricity Network Costs

Energy efficiency improvements in housing – particularly those that lead to reduce space conditioning loads – have the wider societal benefit of reducing peak loads, compared to what they would have been in the absence of the efficiency measure. This means that less network infrastructure is required to cover peak load, and the benefit of this is distributed widely across the economy in the form of lower network charges. Therefore, this benefit is treated as an 'external' or social benefit, as the majority of the benefit accrues to parties other than those who have paid the associated costs – in this case, the owners of 6-star dwellings.

We employ the Conservation Load Factor (CLF) methodology to value these benefits. The CLF methodology was developed in Australia by the Institute for Sustainable Futures and Energetics, and which is now widely used in this kind of analysis.[30] The reduction in peak demand that is attributable to avoided electricity consumption is calculated using the following formula:

[30] ISF/Energetics, *Building Our Savings: reduced infrastructure costs from improving building energy efficiency – Final Report*, July 2010.

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

CLFs are unique to a given end-use. For a specific end-use, the CLF is "…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)". For this study, we refer to CLF values estimated by Jacobs in the context of a review of outcomes of the Victorian Energy Efficiency Target.[31] This study finds that for the Victorian residential sector, values of 0.48 for summer and 0.45 for winter are appropriate. Note that the slightly lower value for winter indicates a *greater* peak demand response in winter than summer in Victoria, which is attributable to the cooler climate.

2.5.7 Unquantified Benefits

It is very likely that 6-star dwellings deliver improved thermal comfort benefits than 5-star dwellings, which could include improved resilience to heat waves, and better health and safety outcomes for occupants, particularly during extreme weather conditions. This stems from first principles, including the fact that unwanted radiant heat and coolth transmission through surfaces, including glazing, can be reduced with higher performance envelopes. The impact of radiant heat for comfort is well known.[32] Also, there will be reduced internal temperature variation and slower heat gain/loss due to better insulation of building envelopes and (potentially) better use of thermal mass. Improved insulation levels and double-glazing can also reduce noise in dwellings, which has been associated with poor mental health.[33]

However, we do not attempt to quantify these effects, primarily due to a lack of quantitative evidence about the extent and value of the benefits, specifically relevant to a change from 5-star to 6-star housing. This change represents around a 12% reduction in annual thermal load,[34] which may not be large enough for quantitative studies to determine outcomes, and to overcome background variation in health and perceived comfort outcomes, unless very large sample sizes were involved. Such studies would mostly likely need to be sustained through at least a full year, if not longer, to examine seasonal effects. As a result, they would be expensive to conduct. Unsurprisingly, we are unaware of any such studies published in Australia to date. Second, because 6-star is a performance-based rather than prescriptive requirement, it is consistent with a wide range of building solutions. These solutions have widely differing designs, envelope solutions, quantities and distribution of thermal mass, materials, finishes and other factors that may well affect comfort and

[31] Jacobs, *Energy Market Impact of the VEET Scheme, Draft Report*, 2 April 2015, Table 15.
[32] See, for example: https://www.resilience.org/stories/2015-03-16/heating-people-not-places-radiant-conductive-heating-systems/
[33] VicHealth, Housing and health research summary, August 2011.
[34] In climate zone 21, Melbourne.

health outcomes, independently from the star rating. Again, an appropriately controlled study of such effects would be difficult to design.

Another unquantified benefit is the reduction in air pollution associated with lower electricity consumption, and thus production, leading to improved air quality, and therefore to potential reductions in morbidity associated with poor air quality. We do not attempt to quantify this benefit, as it rests on numerous assumptions and causal relationships that are uncertain. For example, it cannot be presumed that a reduction in electrical demand in Victoria, due to the 6-star standard, equates to a proportionate reduction in electricity production in Victoria. Indeed, with Victorian brown coal generation having amongst the lowest cost (setting aside external costs) in the National Energy Market, it is very likely that any reduction in Victorian demand would simply have enabled greater exports of electricity to other states, with the same level of local generation and hence air pollution and morbidity. The marginal reduction in generation attributable to the Victorian 6-star standard could occur anywhere in the National Energy Market (NEM), from South Australia to Tasmania and Queensland, which means that the marginal generation unit or units impacted could be wind, hydro, black coal, natural gas or others. In the NEM, the generation mix by fuel type and by state changes at least every 30 minutes and, in reality, virtually continuously. This effect adds considerably to the second uncertainty, which is the *degree* to which a change in air emissions can be associated with a change in health outcomes for specific communities, and with a change in health-related costs. Overall, while a marginal improvement in air quality and health outcomes around Australia due to the Victorian 6-star standard is likely, quantifying the benefit is not feasible.

2.5.8 Incremental Construction Costs

The step up from the 5-star housing standard to 6-star was estimated in 2009 to add between $1,626 (townhouse) and $2,800 (apartment) to the cost of a dwelling in Victoria.[35] In today's dollars, these would be valued at some $2,041 to $3,514. However, the RIS noted that it made the 'conservative assumption' that the incremental capital costs of building at 6-star would remain constant over time, even though it recognised that '…there may indeed be significant cost savings over this life of the policy. For instance, compliance costs could be reduced as more efficient products become available. Similarly, as the industry 'learns' more about energy efficiency a change in practices and methods could also help to lower compliance costs.'[36] For this reason, the rate of change in the incremental cost of compliance over time is known as the 'learning rate'. Also, the costing was based on a DTS or elemental approach, which is generally a higher cost pathway than a modelled NatHERS solution.

Our consultations with industry suggest that designers and builders have indeed found lower cost solutions for 6-star dwellings than was anticipated in 2009. This is consistent with the findings of

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[35] Australian Building Codes Board/The Centre for International Economics, *Regulation Impact Statement for Decision (Final RIS 2009-06)*, December 2009, p. 102.
[36] Ibid, p. 100.

research by Houston Kemp, which suggested that annual incremental costs should decline, on average, by 2% per year – even if that value is likely to vary considerably.[37]

A 2017 study by the Moreland Energy Foundation (in association with Strategy. Policy. Research. et al) did not find any statistically significant results with respect to the learning rate, essentially because the sample size was too low. Overall, based on a sample of 36 Class 1 and 22 Class 2 dwellings across Australia, it found that nominal costs (not adjusted for inflation) rose slightly per square metre over the 2010 – 2017 period, and fell slightly if an allowance for the construction cost index was made. Over the shorter period of 2013 – 2017, and for Class 1 and Class 2 dwellings taken together, an annual learning rate of 7.5% was observed. However, it is noted that this is based on a very limited sample and is not statistically significant.[38]

To add contemporary insights into the actual incremental costs associated with 6-star, Ark Resources worked with Evissa Pty Ltd to cost the necessary changes to a range of 5-star designs to bring them up to 6 (also 6.5) star performance levels. The designs costed are shown in Appendix B, and discussed further in Chapter 5, along with their energy performance simulation results. They include a single-storey house, a 2-storey townhouse, a corner apartment and a mid-building apartment.

Evissa costed each design (or rather, the elements of the design relevant to energy performance, including walls, slab, roof and window specifications) in each of three climate zones (Tullamarine, Ballarat and Moorabbin), with North and South orientations for each, and at 5-star, 6-star and 6.5-star energy performance levels. It should be noted that the incremental cost associated with changing the energy performance of a given dwelling is highly dependent upon its individual design, and whether or not cost minimising design changes are assumed to be made. In this case, we assumed no design changes, which may tend to over-state the actual costs that may be incurred. Costs, averaged across the two orientations, are shown in Table 5.

	Tullamarine	**Ballarat**	**Moorabbin**
	Single Storey House		
5-star	$114,001	$114,017	$113,959
6-star	$115,825	$116,050	$115,362
6.5-star	$119,091	$119,225	$117,947
5 - 6-star	**$1,824**	**$2,033**	**$1,403**
6 - 6.5-star	$3,266	$3,175	$2,584
	2 Storey Townhouse		
5-star	$94,069	$94,176	$94,176
6-star	$98,742	$98,849	$98,742
6.5-star	$99,664	$99,664	$99,630
5 - 6-star	**$4,673**	**$4,673**	**$4,566**

[37] Houston Kemp, *Residential Buildings Regulatory Impact Statement Methodology*, April 2017, p. 22.
[38] Moreland Energy Foundation Limited et al, *Changes Associated with Efficient Dwellings Project – Final Report*, May 2017, p. 39.

	Tullamarine	Ballarat	Moorabbin
6 - 6.5-star	$922	$815	$888
	Corner Apartment		
5-star	$62,618	$62,608	$62,537
6-star	$63,591	$63,049	$63,059
6.5-star	$64,038	$64,278	$63,476
5 - 6-star	**$973**	**$441**	**$522**
6 - 6.5-star	$447	$1,228	$418
	Mid Apartment		
5-star	$53,729	$53,729	$53,934
6-star	$54,185	$54,231	$54,231
6.5-star	$54,437	$54,500	$54,523
5 - 6-star	**$456**	**$502**	**$297**
6 - 6.5-star	$252	$269	$292

Table 5: Costing Summary ($FY2019 real per dwelling)

The townhouse stands out as having higher incremental costs to attain 6-star performance. Ark Resources notes that townhouses tend to have more floors, more compact rooms, and a smaller overall area, meaning a higher ratio of façade to floor area. This places additional focus on the thermal performance of façades, and of glazing in particular. Ark Resources notes that it is common for 6-star townhouses in Victoria to be double-glazed. At the same time, the incremental cost for lifting the performance of such townhouses to 6.5-star is relatively small. Indeed, this is also the case for the apartment forms modelled. This is because most designs and climate zones (modelled) require the more expensive change from single to double-glazing at around the 6-star level, while only marginal glazing specification changes are required to then reach 6.5-stars.

For example, townhouse is modelled with higher insulation levels for 6.5-star, enabling slightly less costly glazing than for 6-star, with net effect of these two being a very small increase in overall costs. For the detached house, the step from 6 to 6.5-stars is modelled using an increase in glazing specifications only, and these are somewhat larger (than for the townhouse), notably in Ballarat.

Overall, we urge caution in interpreting these cost results. Every design is unique, and the costs associated with upgrading them depend upon design and specification choices made by designers, client preferences and other factors. Therefore there can never be a unique and definitive incremental cost associated with a given change in star rating. To achieve a representative cost would require costing changes to a large sample of designs in a large number of locations, and that is beyond the scope of this exercise. For this study, and since we have only cost observations from 2009 and from 2018, we assume a linear progression over time between these two observations.

Other Costs

The 2009 RIS notes that there could have been additional cost classes associated with the introduction of 6-star, including additional compliance and enforcement costs, and additional maintenance costs. However, there is no evidence that there has in fact been additional expenditure on Code compliance and enforcement attributable to the introduction of 6-star. Indeed, the majority of stakeholders interviewed suggested that considerably more attention should be paid to compliance and enforcement. However, the decision whether or not to do this is independent of the level of stringency of the Code. Therefore, there is no basis for attributing incremental costs for compliance and enforcement to the 6-star standard. Indeed, the RIS acknowledged that there would be no additional:

- Operating or maintenance costs
- Design feeds
- Costs associated with thermal performance simulation
- Other costs. [39]

2.5.9 Benefit Cost Analysis Indicators

The key BCA indicators presented in Chapter 6 include:

- Present values of costs and benefits
- Net present values
- Benefit cost ratios.

Present values are a technique designed to enable comparisons of values (costs and benefits) that occur in different time periods. For this evaluation, we assume that the 6-star standard applies from FY2012 (the first full year of application) through to FY2019 (at least), with the tail of economic benefits enduring for the economic lives of the dwellings. The present value of costs and benefits is determined first by establishing the annual real, or inflation-adjusted, values in each year, and then discounting the values to a fixed point (generally, in this analysis, in the past, as discussed further below), using a real discount rate. Discounting is separate from inflation adjustment and is intended to represent the phenomenon of time preference – or the tendency of people to value events in the near term more highly than those in the future. This is controversial in the presence of effects such as climate change, as discounting will make the present value of future costs appear smaller. In some cases, a lower discount rate is applied to government regulations that are intended to have long-term social and environmental benefits. In this study we apply the real discount rate recommended by the Victorian Department of Treasury and Finance for 'Category 1' projects of 4% real as the default value.[40]

As this study involves values that occur in the past, present and future, the treatment of time is important to the analysis, as discussed in Section 2.5.3. Therefore, in addition to adjusting values

[39] ABCB (2009), p. 103.
[40] Department of Treasury and Finance, *Victorian Guide to Regulation, Toolkit 2: Cost-benefit analysis*, July 2014, p. 11.

as needed to a real or inflation-adjusted basis, when we calculate present or net present values for periods in the past, we then need to inflate those values to reflect the effect of price inflation over time. Importantly we inflate costs and benefits equally, such the benefit cost ratios are unaffected. For this step, we use the Victorian Consumer Price Index.[41]

2.6 Impact and Benefit Cost Analysis Method – Solar Hot Water

Conceptually, the same approach is brought to the impact and benefit cost analysis as for energy above. We start by capturing data on 'what happened', and then data on the associated values, direct and indirect, costs and benefits. The measures commenced in 2005 and are modelled as applying from that date to the end of FY2019. No assumptions are made about the measures after June 2019.

2.6.1 Solar Hot Water Heater/Rainwater Tank Uptake

The Victorian Building Authority (VBA) issues building permits for new Class 1 dwellings, *inter alia*, and – in the process – captures data on whether those permits are issued with provision for a solar hot water system, a rainwater tank (or neither). We note that the original data from VBA shows between 70% - 80% of the Class 1 permits issued annually declare whether a rainwater tank or a solar water heater has been selected. The Department understands that this is likely to reflect two factors:

1. non-reporting of the choices made (rather than non-compliance)
2. building permits that covering multiple dwellings.

On this basis, the revealed shares of households choosing solar hot water and rainwater tanks were grossed up to 100%, to estimate the choices likely to have been made by those dwellings not reported. On this basis, it appears that solar hot water is chosen by around 70% of new homeowners, with this share having increased somewhat over time. The BESS data was also reviewed for data on solar hot water uptake.

[41] Australian Bureau of Statistics, *6401.0 Consumer Price Index, Australia, TABLE 5. CPI: Groups, Index Numbers by Capital City*.

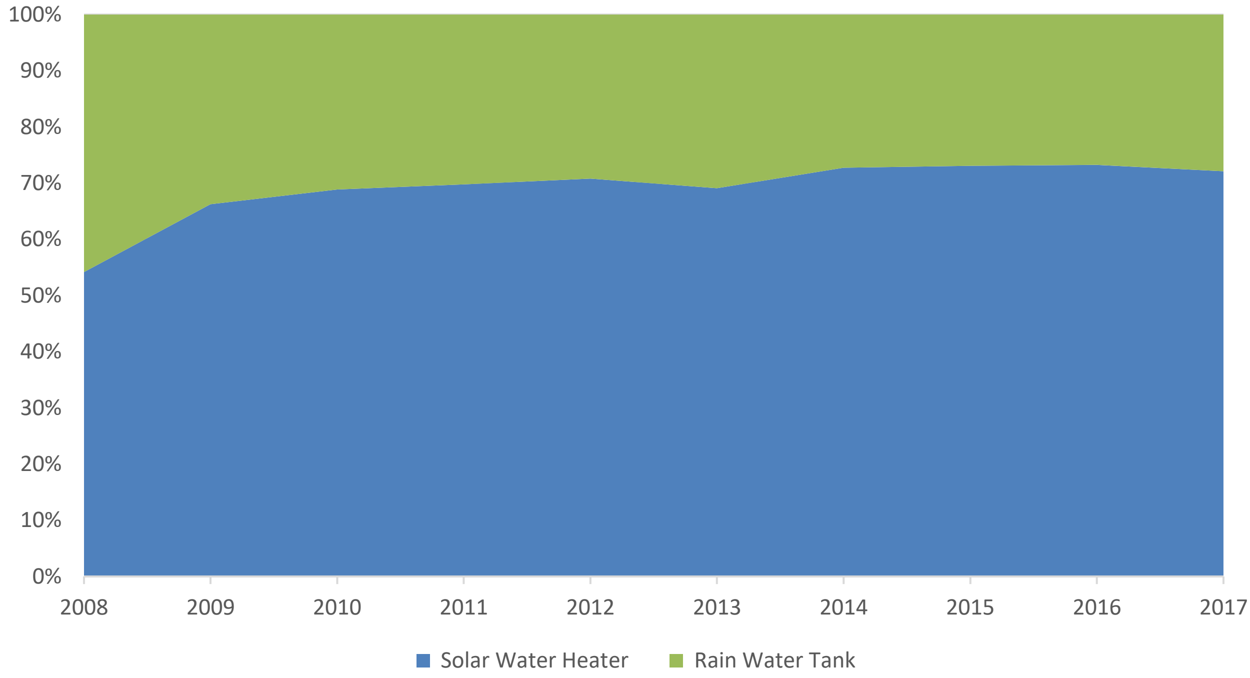


Figure 5: Solar Hot Water vs Rainwater Tank Choices, New Class 1 Dwellings

2.6.2 Solar Hot Water Heater Analysis Method

Analysis of the impact of the solar hot water provision was constrained by a lack of data regarding the choices made by new Class 1 dwelling owners about hot water technologies and fuels. Apart from the VBA data on gas-boosted solar hot water uptake by year since 2008, the only other directly applicable sources were the 2009 RIS, which provides an observation of the hot water mix in new dwelling at that time, and a BIS Shrapnel report covering the 2011 year.[42] We understand the latter report has since been discontinued.

In principle, we wish to know what the impact of the plumbing regulations has been relative to a counter-factual scenario in which the regulations were not introduced. This means that some assumptions also have to be made about the nature of that counter-factual scenario, such as what the policy environment would have been and what mix of hot water systems (for new dwellings) would have been expected over time. Broadly we assume that, in line with national outcomes, BCA2010 would have applied in Victoria from May 2011 (without variations), and this introduced a requirement to use low-carbon energy sources for 'domestic services' (hot water). In effect, this prevented the installation of electric storage hot water systems in all states (except for Tasmania due to its relatively low emissions intensity of electricity consumption), and it would also have done so for Victoria. Therefore for the counter-factual scenario we assume that electric storage systems would no longer have been installed in new Victorian dwellings from FY2012 onwards.

[42] Excerpts only were provided by the Department due to the confidential nature of this Report.

The broad trends in hot water sales by type in Victoria are included in the data and projections in the 2015 Residential Baseline Study.[43] This source shows a model of the total stock of all hot water systems in Victoria by year. The change in annual numbers of systems is indicative of at least expected changes in sales by type year on year. However, the model includes sales for replacements of systems in existing homes (and sales for all other purposes), in addition to sales to new Class 1 dwellings. Also, trends may have changed since this data was published. With these limitations, the trends include declining shares of electric and gas storage systems, a rising share of instantaneous gas systems, growing but modest uptake of solar and heat pump systems (in the absence of the policy measure).

The hot water technology and fuel mix employed in this study were varied following feedback from the Department and other stakeholders about the scenarios considered most likely or plausible. They remain assumptions in the absence of concrete data, but at least reflect a range of expert opinion. As discussed in Section 2.2.4, Data Limitations, this study does not purport to be a detailed study of Victorian hot water market over the period since 2005.

The resulting table of assumptions for the counterfactual scenario (without the plumbing regulations) is shown in Table 6, while the 'with measures' scenario assumptions are shown in Table 7. Several industry stakeholders noted that instantaneous gas hot water should be considered the primary hot water choice in the counter-factual scenario, due to its relatively low capital (which some noted had come down over time in real terms) and operating costs, and high system efficiency, particularly for households with modest hot water consumption. As noted in Table 6, we assume this technology would have accounted for around 60% of recent new-build sales in the absence of the plumbing regulation provisions.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electric Water - Med/Large	12%	12%	11%	11%	10%	10%	0%	0%	0%	0%	0%	0%	0%	0%
Gas instant (mains)	39%	41%	42%	42%	45%	47%	57%	57%	57%	58%	59%	60%	60%	61%
Gas storage (mains)	44%	41%	38%	36%	30%	27%	26%	25%	24%	22%	20%	18%	16%	14%
Heat pump	2%	2%	3%	4%	5%	6%	7%	7%	8%	8%	9%	9%	9%	10%
Solar electric	2%	2%	3%	4%	5%	6%	6%	7%	7%	8%	8%	9%	9%	10%
Solar gas	1%	2%	3%	3%	5%	5%	5%	5%	5%	5%	5%	5%	6%	6%
Totals	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 6: Hot Water System Share Assumptions – BAU/Counterfactual Scenario (without plumbing regulations)

43 http://www.energyrating.gov.au/document/2015-data-tables-residential-baseline-study-australia-2000-%E2%80%93-2030, viewed 27/12/2018.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electric Water - Med/Large	10%	8%	8%	**4%**	5%	**5%**	4%	3%	2%	1%	1%	1%	1%	1%
Gas instant (mains)	24%	22%	21%	**18%**	22%	**20%**	26%	29%	24%	26%	27%	29%	30%	31%
Gas storage (mains)	25%	20%	20%	**10%**	17%	**17%**	16%	15%	14%	13%	12%	11%	10%	9%
Heat pump	1%	1%	1%	**2%**	2%	**2%**	2%	2%	2%	2%	2%	2%	2%	2%
Solar electric	3%	4%	5%	**15%**	6%	**6%**	6%	6%	6%	6%	6%	6%	6%	6%
Solar gas	37%	45%	45%	**51%**	48%	**50%**	46%	45%	52%	52%	52%	51%	51%	51%
Totals	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 7: Hot Water System Share Assumptions – 'With Measures' Scenario (with plumbing regulations)

A second source of data uncertainty is the average energy use of each hot water type in typical new-build households. Previous work commissioned by the Department found considerably lower rates of daily average hot water consumption than assumed under the STC methodology, for example.[44] Adopting this data meant that the average annual energy consumption for all hot water systems was lower than it would have been under the STC method, for example, which in turn means that the savings available from switching hot water technologies were reduced. However, the Department understands that the lower consumption values are more representative of actual consumption practices, and therefore these values were used in this study.

The benefit cost analysis assumes bulk buy discounts of 15% relative to the pricing suggested in Cordells Cost Guide, but because this assumption is assumed to apply equally to all hot water types, it does not change the cost relativities associated with switching.

Further details of the methodology for each element of the analysis is set out in Chapter 6.

[44] Energy Efficient Strategies, unpublished.

3. Literature Review Summary

3.1 Energy References

We cannot find any previous studies that directly set out to evaluate the 6-star standard in Australia. However, the references detailed in Appendix 1 help to illuminate some key aspects of the evaluation and related issues.

A 2017 study by the Moreland Energy Foundation, SPR and others examined how the residential buildings sector (Australia-wide) responded to the introduction of the 6-star energy efficiency standard and how these responses have changed over time. Key changes included an increase in the performance specifications of glazing and insulation. Industry respondents agreed there was an added cost associated with the introduction of these requirements, although views differed widely about that extent of that increase. The quantitative research found modest incremental costs of $18/sqm for Class 1 dwellings and $7/sqm for Class 2. An annual industry learning or cost-reduction rate of 7.5% was found over the 2014-2017 period (7.1% for Class 1 dwellings and 1.7% for Class 2). However, none of the findings were statistically significant due to the low sample size of 60 dwellings Australia-wide and also covering a time period of 7 years.

The 2009 Regulation Impact Statement by The CIE is relevant because it documents the outcomes that were expected of the 6-star standard at that time. The key finding was that the proposed standard was expected to be slightly less than cost-effective, Australia-wide, assuming a real discount rate of 7 percent, with an overall benefit cost ratio (BCR) of 0.88 (values above 1 would be considered cost-effective). Results for Victoria (Melbourne climate zone) were expected to be similarly negative. The present net value of the impact of thermal and lighting provisions on dwellings, at a 7 percent discount rate, was averaged at -$29/dwelling for houses, -$531 for townhouses and -$1337 for flats. The estimated BCR, under the same conditions, was calculated at 0.98 for houses, 0.61 for townhouses and 0.52 for flats. At this same time, this document was criticised at the time for assuming constant costs of compliance over time (no industry learning). Potentially the largest deviation between the assumptions of this study and reality has been the very large increases in real energy costs that have occurred, and which were not anticipated. If they had been, BCRs would have been much higher.

A 2012 study by RMIT focused on opportunities for upgrading the environmental improvement of the existing housing stock. It found that extensions had much higher levels of ceiling, wall and floor insulation than did the pre-existing houses, and also were more likely to use double glazing. The installation of water tanks also rose from 3% before to 47% following renovation.

A 2013 study by pitt&sherry found that the environmentally efficient design planning policies of Banyule, Moreland, Port Phillip, Stonnington, Whitehorse and Yarra – which called for an additional 10% energy improvement relative to the 6-star standard – were highly cost-effective. It concludes that each of the four building/development types examined – small multi-dwelling residential buildings, small residential extensions, large multi-unit residential buildings and small commercial buildings – show a clear net benefit when EED policies are applied, as opposed to a scenario in which they are not. The present value of benefits exceeded those of costs (at a 7 percent discount rate) by between 3.1 and 6.8 times, with a simple investment payback period of between 1.8 and 4.9 years.

A 2013 study by the Allen Consulting Group considered the likely cost-effectiveness of higher energy efficiency standards for NSW housing under BASIX, which is a NSW variation that replaces the 6-star standard in that state. Overall, it found that the proposed increase in stringency to the BASIX policy would have generated a net benefit of around $510 million, with a BCR of 1.64. Further, it found that the proposed changes to BASIX could have been implemented at a negative cost; with the outcomes being positive for both individual households and the NSW community at large. We note that BASIX standards were in fact not lifted until 1 July 2017.

An Australian Greenhouse Office study from 2000 found that Building Code of Australia provisions that applied in Victoria from 1991 to 2000 (EES, 2000) led to an average improvement in thermal efficiency of 40% over this period; 36 percentage points of which occurred almost immediately after the implementation of the regulations in 1991, but only 6% more over the course of the decade. This pattern is consistent with standards that were easily able to be met, and a market where non-regulatory pressures for efficiency improvement appear to have been weak.

The recent 2018 study by the Australian Sustainable Built Environment Council (in which SPR was a delivery partner) found that lifting energy standards for new buildings in the National Construction Code could, between now and 2050, reduce energy bills by up to $27 billion, cut energy network costs by up to $7 billion and deliver at least 78 million tonnes of cumulative emissions savings.

Overall, this literature appears to suggest that the expectation in 2009 that the 6-star standard would not be cost-effective was very rapidly overtaken by events, and notably the significant increase in energy prices since that time. Also, it appears likely that that study over-estimated incremental costs, particularly the declining path of incremental costs over time. More recent studies show positive to very positive benefit cost analysis results for 6-star or beyond performance.

3.2 Solar Hot Water References

For the solar hot water element of the plumbing regulations, the only directly relevant reference is Allen Consulting Group (2004). This is a benefit cost analysis of the prospective water efficiency, rainwater tank and solar hot water heating regulations for that were proposed to accompany the 5-star standard in Victoria.

4. Consultations

4.1 Introduction

Ark Resources and SPR conducted a series of structured interviews with key building industry stakeholders in Victoria. The aim was to achieve a broad coverage of companies engaged in a range of industry segments, such as those specialising in different dwelling types, and from the design team, industry bodies and those involved in project delivery – see Table 8.

Profession	Role	Years experience in Vic residential sector
Architect	Director	8
Architect	Director	21
Architect / PassiveHouse certified consultant / NatHERS accredited assessor	Director	11
PassiveHouse certified consultant	Director	10
Energy analyst & consultant	Principal	10
Energy analyst & consultant	Managing Director	30
Energy analyst & consultant	Consultant	30
Energy analyst & consultant	Managing Director	30
Energy analyst & consultant	Managing Director	40
National Energy Efficiency Council	Head of Policy	20
Façade engineering consultant	Senior consultant	8
Façade fenestration consultant	General Manager	20
House-builder / designer	Director	17
Air-tightness testing & Resi Scorecard consultant	Managing Director	3.5
Registered building surveyor	Director	30
BDAV	CEO	34
Insulation manufacturer	Managing Director	20
Window and frame manufacturer - aluminium	Architectural Specifier	5
Window and frame manufacturer - uPVC	Director	26
Glazing product manufacturer	BD Manager	15
		388.5

Table 8: Overview of Stakeholders Consulted

The detailed write-up of these interviews can be found at Appendix C, while a summary is provided below. The Department and Sustainability Victoria are separately engaging with the volume building market through the Zero Carbon Homes and other projects. Hence this consultation targeted other practitioners and industry participants, approached by the report authors based on their experience on relevant topic areas over the timeframes of this evaluation report.

All designers interviewed have experience of delivering dwellings exceeding statutory compliance. Many manufacturers and specialists interviewed had relevant experience with commercial factors associated with high-performance glazing systems and impacts on the supply-chain associated with awareness, cost-sensitivities, and product supply and demand.

Interviewees were provided in advance with the questionnaire and the following timeline of contextual events over the last decade, drafted as an aide-memoire to help prompt relevant comments and perspectives. Interviews were generally conducted by phone working through the questionnaire in a conversational manner with key responses written-up from interview notes.

4.2 6-star Performance Requirement

The consultation process drew insights into a wide range of topics. Many weaknesses or challenges identified within the process of delivering improved star ratings may be considered relatively easy to tackle or improve through enhanced regulations, policies, guidance or compliance process.

The stakeholders most intimately involved with supply-chain dynamics are the manufacturers and importers/suppliers. It is however evident that passionate designers and energy consultants take time to educate themselves about high-performance products and have developed good understanding of market dynamics associated with awareness, and marketability of such products or their attributes, local availability/competition, and the evolving cost-sensitivities of their clients. In relation to supply chain trends these stakeholders reported that:

- Increased stringency of energy standards has stimulated significantly increased local manufacturing capacity for higher performing insulation and fenestration products. Market has changed from mostly single-glazed to mostly double-glazed since introduction of 6-star standard. A new glass manufacturing facility built last year in Geelong is considered to be of world-class standard and was built with financial support from state government. It is expected to transform availability and cost of insulated glass units (IGUs), and circumvent risks associated with imported windows. Weaker exchange rates since the mining boom have also helped boost demand for local product.

- Increased stringency of energy standards has also stimulated import demand for cost-effective high-performing fenestration products, particularly double-glazing and (to a lesser extent) IGUs. These are already produced overseas in large volumes in countries with more stringent energy-efficiency legislation and colder climates.

- A significant gap in the Australian manufacturing sector is the absence of a facility to deposit soft low-e coatings onto glass in order to make double- or triple-glazed IGUs; i.e., vacuum-depositing. Hard low-e coating is achieved locally through pyrolytic process. Hard low-e coating is less effective and is typically associated with single-glazing applications e.g. for retail shopfronts.

- A high-performance uPVC window frame profile extrusion facility has recently been built in NSW, with state government support. This investment is in response to recently rising demand particularly in the renovation sector. Demand for uPVC windows is perceived to be less driven by energy performance regulations for new-builds than increasing value awareness and thermal and acoustic comfort expectations. Mandatory home energy rating disclosure on sale or lease in ACT was cited as an important driver i.e. ACTHERS not NatHERS. Demand is currently outstripping industry capacity driving up installation costs.
- For those stakeholders who have needed to interact with it, WERS (Window Energy Rating System) has not kept pace with transforming commercial demands of the residential fenestration sector over recent years. It is regarded as 'broken', increasingly irrelevant and not worth fixing. Given the importance of glazing in overall energy performance outcomes of dwellings, this is a significant finding.
- Many in the architectural community are not au-fait or on-board with energy-efficiency, with particularly poor understanding of glazing performance parameters noted in some cases. Aesthetics are commonly prioritised at the expense of performance, with corresponding lack of ownership of responsibility.
- Government-level interventions would be welcome in terms of:
    - incentives for high-efficiency products and outcomes
    - supply-chain transformation through phased prohibition of worst-performing products, e.g., single-glazing, uncoated glazing, unimproved aluminium window frames etc.
- Enforce compliance around product standards as well as building code standards. Fenestration is a key area where the energy performance of what gets delivered to site can be much less than that committed and certified.
- Feedback was also received regarding the advantages for industry of a fixed roadmap towards carbon-neutrality rather than incremental improvements to regulations, which provide much less certainty in terms of capacity-building.

The last decade has seen falling prices and wider availability in Australia of other imported energy-efficient products such as LED lighting, solar photovoltaic and battery storage technologies. The most notable current transformation in Australian supply-chain capacity is the establishment of domestic solar battery manufacturing facilities for 3 international companies. These new facilities are all in South Australia and it is notable that these investment locations have been triggered by policies introduced at state-government level.

Stakeholders associated with design, modelling and delivery of developments made the following observations:

- NatHERS modelling and certification has been of variable quality, sending confusing signals to the market though compliance standards are improving. Mandatory assessor registration and certification would help improve standards.
- Alternative compliance pathway NCC Section J V2.6.2.2 was not widely known, but those who have used it are aware of its potential to be used as a 'softer' route to compliance. This impact of this choice on net social benefits associated with the 6-star regulation is not known but should be investigated.
- Many energy consultants expressed concerns regarding longstanding assumption or algorithm flaws within the calculation engine used by NatHERS software, particularly around climate and occupancy patterns. These can lead to inadequate predictions of cooling loads and distorted outcomes such as design solutions that could increase overheating risk.
- Broad agreement that more stringent compliance thresholds would not be onerous or costly to deliver, a message that is at odds with the longstanding public position of certain industry associations.
- There was virtually uniform agreement that dwellings are not being built to the performance standards stated, and that building surveyors are inconsistent and ineffective in policing this, partly due to inherent bias towards policing potential non-compliances that may affect safety, rather than efficiency, outcomes. There was no consensus on simple ways to effectively rectify this situation, other than improving guidance for surveyors and raising awareness and education amongst consumers.
- A number of architects and assessors with involvement at site stage have invested in tools such as consumer-grade thermography cameras to assist in the detection of non-compliance during construction. One architect interviewed also installs time-lapse cameras on house sites, which have proved useful for identifying defects such as missing insulation that may otherwise go undetected.
- Owner-occupiers have greater vested interest in energy performance compliance than investors or developers of Class 2 developments so are more likely to be prepared to pay a premium for enhanced compliance checking.
- Generally, only those involved with delivering higher performing dwellings were aware of the lack of regulation around the thermal performance of external doors (other than sliding doors covered by glazing performance requirements). Insulated doors with durable, high-performance seals are common in northern Europe and form part of energy rating assessments.
- Consumers were observed to be increasingly paying more for aesthetic design features such as stone benchtops, feature front-doors, etc, despite these costing more than improved energy ratings, which generate a return on investment. These choices have had

a significant impact on the cost of homes, to a much greater degree than energy performance requirements. The benefits of higher star-rated dwellings in terms of improved thermal/acoustic comfort levels and increased useable space may be more significant for consumers than simply changes in energy running costs.

Consultations indicated general support for:

- Greater education and awareness, e.g. through mandatory disclosure of dwelling energy performance on sale or lease.
- Increased minimum NatHERS rating stringency and other minimum standards (e.g. mandatory certification, mandatory air-tightness, mandatory double-glazing) - with adequate notice periods for the service/supply chain to evolve. Victoria should continue to be a leader in policy-setting.

Opinions were most polarised on the topic of whether the industry had learnt from experiences over the last decade of transitioning to 6-star and often beyond, and whether less effort was now involved. We consider it likely that the diversity of experiences indicates considerable patchiness in learning rates experienced across developers, design team members and the supply-chain. Those who feel the process has gotten much easier may be more motivated to self-educate and actively seek out solutions that allow them to 'work smarter not harder'. Also, there is a significant distinction to be made between industry leaders, who are keen to adapt and be motivated by 'carrots' such as awards or sense of achievement, versus 'laggards' more likely to respond only to 'sticks', such as if there were punitive consequences associated with non-compliance with standards.

It is also apparent that those who are successfully achieving high performance outcomes regularly seek to work alongside developers, designers and constructors who have shared similar journeys and successes, and who have built up familiarity with potential trip-hazards. Relationships built over previous collaborations provide common understanding, the collective experience is more productive and rewarding, and therefore also more profitable.

Design advice and compliance motivations also differ with procurement routes and ownership. Volume house builders and their designers can be considered less accountable to their clients than individually-commissioned homes. The volume housebuilder market is also geared to disincentivise progressive designs or products to minimise diversions from templated norms, though some players are demonstrating willingness to evolve. Class 2 developments are typically built by development entities that do not exist beyond conclusion of the developments defects liability period so frequently lack long-term interest in asset performance, financial or otherwise.

4.3 Solar Hot Water

As part of our consultation process, we interviewed representatives of rainwater tank and solar hot water supply-chains about the factors influencing the choice between procuring these alternative compliance measures. Most agree the choice does not appear logically equivalent; i.e., energy-saving vs water-saving measures. Both are considered more expensive requirements than BCA Volume 2 Part 3.12.01 heating and cooling load compliance, and generally they are not favoured by industry. The following summarises the opinions gathered, without attributing comments to particular stakeholders, focusing on comments relating to solar hot water. Where comments were also made with respect to rainwater tanks, these are recorded in Appendix C.

Solar Hot Water

For solar hot water systems, there is evidence that sales volumes for the new-build housing sector are higher in Victoria than other states, which is attributed to or at least influenced by the Victorian variation to BCA Volume 2.

Industry contacts indicate that well over 90% of solar hot water panels installed are of the flat-plate collector type. Flat-plate collectors are cheaper but less energy efficient than the evacuated-tube panel alternative, which is more efficient both in terms of energy harvesting - particularly in diffuse light and sub-optimal orientation conditions - and in terms of heat retention.

Manufacturer consultation indicated that flat-panels are particularly prone to frost-related failures and typically have 5-year warranties as opposed to 15 years for evacuated tube collectors. One manufacturer felt this was exacerbated by increased prevalence of frost associated with climate change.

It was reported that low-quality flat panels are frequently procured by builders based on minimum cost and fail well before 5 years. It was also observed that these panels are often installed by plumbing apprentices, increasing the risk of system failure due to poorly made joints failing within 5 years. The Victorian plumbing regulations allow systems to be installed by apprentices under the supervision of a licenced plumber.

Compliant design requirements of solar hot water systems could be made more accessible. Requirements for the solar hot water system to perform to at least 60% solar contribution are buried in VBA Technical Solution Sheet 6.13 2013, which is not referenced in VBA Practice Note 55: 2014. This technical sheet also references the need for frost protection, but the wording appears indecisive. The 60% solar contribution requirement is also specified within the Victorian plumbing regulations. The regulations do not reference frost-protection.

Consultant stakeholders engaged within the formal interview process questioned the level of product compliance of both solar hot water panels and electric heat-pumps with relevant Australian Standards.

There are restrictions on the use of electric heat-pump hot water systems, which would benefit from extensive review given:

- improving efficiencies of heat-pumps
- falling carbon-intensity of grid-electricity in Victoria.

In recent years solar hot water panels are increasingly competing for limited roof space against solar photovoltaic systems, which have the following advantages:

- better warranted life span
- minimal maintenance requirements
- remote performance monitoring
- generous state funding of domestic rooftop PV via Solar Victoria
- generous time-varying feed-in-tariffs implemented by the Victorian Essential Services Commission.
- strong synergy with electric heat pumps and immersion heaters as energy storage devices at times of surplus PV power generation.
- better economic return-on-investment over lifespan.

5. Simulation Modelling

5.1 Introduction

Ark Resources was commissioned to undertake simulation modelling on a range of dwelling types to verify the extent and nature of changes made to typical designs to move from 5 to 6-star, and also to 6.5-star, noting the number of LGAs that effectively call for 6.5-star through BESS or other planning provisions. The dwelling archetypes used for this analysis are as follows:

- Detached, single storey 4-bedroom house
- Semi-detached (duplex) two-storey 3-bedroom townhouse (end of row)
- Mid-level, mid-terrace 2-bedroom apartment
- Mid-level, corner 2-bedroom apartment.

Single-storey detached houses are the most common typology being built in outer suburbs and regional towns.

Street-facing detached duplex townhouse subdivisions are commonly built in interface suburbs as redevelopments of existing blocks originally developed as single homes over previous decades. These sites typically have broader block widths than is common in current new-build sites planned in the outer suburbs. This typology is also representative of end-of-terrace townhouses. Mid-terrace townhouses (with two party walls) are not modelled in this exercise but may be expected to perform somewhere between a semi-detached townhouse and a mid-level corner apartment.

All typologies modelled in this report are based on commercially-developed designs that have met the necessary planning codes and standards and been built as documented. The apartments

Plans and elevations for these typologies are depicted in Appendix B.

NatHERS modelling was carried out to achieve 5-star, 6-star and 6½ star ratings for each of the 4 dwelling typologies, for all 4 orientations (North, South, East and West). Additionally, this exercise was carried out for 3 differing climates (Melbourne West, Melbourne East and Moorabbin).

This exercise therefore generated 144 modelling permutations; that is, 48 per climate zone.

The purpose of the simulation modelling was to cross-check the feedback from industry about the kinds of typical changes that were made to 5-star designs to achieve 6-stars (or 6.5-stars in some local government areas), and also to calculate the incremental costs associated with these changes.

5.2 Typical Building Fabric Composition for Typologies and Star Ratings

Table 9 to Table 12 below summarise the key building specification changes necessary to enable the typologies modelled to achieve the noted star ratings.

Table 9: Single Storey Detached House

NatHERS rating	Wall insulation m²K/W	Glass	Window frame	Roof insulation m²K/W	Floor slab	Average cost premium per uplift
5-star	R1.5 - 2.0	Single-glazed, clear	Aluminium	R4 - 5	Concrete	-
6-star	R2.0 - 2.5	Single-glazed, clear	Mostly aluminium, One timber-framed sliding door	R5 - 6	Waffle Pod	$1,753
6½ star	R2.5	Double-glazed, clear	Mostly aluminium, One timber-framed sliding door	R6	Waffle Pod	$3,008

Table 10: Double-storey, Semi-Detached Townhouse (end of row)[45]

NatHERS rating	Wall insulation m²K/W	Glass	Window frame	Roof insulation m²K/W	Ground floor slab	Average cost premium per uplift
5-star	R1.5 - 2.0	Single-glazed, clear	Aluminium	R3-4	Concrete / Waffle Pod	-
6-star	R2.5	Some single-glazed, mostly double-glazed	Aluminium	R3.5-5	Waffle Pod	$4,637
6½ star	R2.5	Double-glazed, clear, low-e, argon	Aluminium	R4-5	Waffle Pod	$875

Table 11: 2-bedroom balcony apartment – mid-level, mid-row

NatHERS rating	Wall insulation m²K/W	Glass	Window frame	Neighbouring ceiling	Neighbouring floors	Average cost premium per uplift
5-star	R1.5 - 2.0	Single-glazed, clear	Aluminium	Concrete slab	Concrete slab	-
6-star	R2.0 – 2.2	Single-glazed, some double, glazed or low-e	Aluminium	Concrete slab	Concrete slab	$418
6½ star	R2.0 – 2.2	Double-glazed, clear, some low-e	Aluminium	Concrete slab	Concrete slab	$271

Table 12: 2-bedroom balcony apartment – mid-level, corner

NatHERS rating	Wall insulation m²K/W	Glass	Window frame	Neighbouring ceiling	Neighbouring floors	Average cost premium per uplift
5-star	R2.0	Single-glazed, clear	Aluminium	Concrete slab	Concrete slab	-
6-star	R2.0 – 2.2	Single-glazed, some double, glazed or low-e	Aluminium	Concrete slab	Concrete slab	$645
6½ star	R2.0 – 2.2	Double-glazed, clear, some low-e	Aluminium	Concrete slab	Concrete slab	$698

Detailed simulation results for each typology, climate zone and orientation modelled can be found in Appendix C.

[45] Therefore having one party wall.

5.3 Interpretation and Commentary

5.3.1 Climate sensitivity

In order to establish whether climate was a significant consideration in this exercise all typologies and orientation combinations were assessed across differing climates:

- Melbourne west (Tullamarine) 138MJ/m² for 6-star
- Melbourne east (Moorabbin) 125MJ/m² for 6-star
- Ballarat 197MJ/m² for 6-star

These climate zones were judged to be representative of regions within Victoria having experienced high volumes of new housing over the last decade.

Victoria's climate combined with typical residential occupancy patterns typically requires around 3 times as much heating energy as cooling across the whole year. Ballarat has a generally cooler climate than Melbourne's three residential climate zones. As can be seen from above, a 6-star dwelling in Ballarat has a 58% higher intensity of fabric energy load across the year than a 6-star dwelling in Moorabbin. This is because NatHERS rating scales are automatically adjusted by climate zone. If anything, the modelling data generated from the selected typologies suggests that NatHERS compliance in Ballarat can be very slightly easier in Ballarat than in Melbourne.

In general, this modelling demonstrates that these typical rating bands for different climate regions serve their intended purpose of providing equivalent stringency in terms of dwelling envelope performance provision regardless of building typology or NCC classification.

On this basis there is therefore no evidence to suggest that achieving a given star rating is significantly more or less onerous across these regions. There is therefore no evidence that from a capital cost perspective, regulatory threshold adjustments relating to NatHERS ratings should account for climatic differences, beyond that which is intrinsic to the rating system.

Since gazetting of the Better Apartment Design Standards (BADS) in 2017 all apartments have to meet a cooling cap dictated by climate zone, under the Victorian Planning Scheme. For the chosen climates these are:

- Melbourne west (Tullamarine) 22MJ/m²
- Melbourne east (Moorabbin) 21MJ/m²
- Ballarat 23MJ/m²

For Melbourne (central) climate zone the cooling cap is set much higher at 30MJ. However as per NatHERS ratings, experience has proven that stringency (compliance measures) for BADS cooling cap compliance is comparable between zones as intended, so the inherent factors dampening climate sensitivity in the system appear to prevail.

5.3.2 Star-rating target implications for building fabric

Given relative insensitivity to climatic variations the following building element attributes are also generally apparent across the housing typologies assessed:

Walls

5-star: 10-20mm of rigid polystyrene board on battens was typically adequate.

6-star: 20mm of rigid polystyrene board on battens or around 100mm of bulk insulation was typically adequate.

6½ star: similar to current (6-star).

At these NatHERS compliance levels wall insulation values higher than R2.5 show diminishing benefits relative to cost and comfort considerations. Slightly higher levels of wall insulation are required for house and townhouse typologies studies due to wall to floor area ratios being higher than for apartments.

Roofs

5-star: 150mm of bulk-fill insulation was typically adequate. e.g. R=3-4m²K/W

6-star: 150 – 200mm of bulk-fill insulation is typically adequate.

6½ star: 200mm of bulk-fill insulation is typically adequate e.g. R=5-6m²K/W

Slightly higher levels of roof insulation are required for singles-storey houses due to roof to floor area ratios being higher than for two-storey townhouses.

Ground slabs

5-star: concrete on ground was typically adequate.

6-star: insulated waffle-pod slabs are typically adequate.

6½ star: as per 6-star.

Insulated waffle pod slabs are now commonplace in the Victorian housing market. They incorporate expanded polystyrene as permanent void formers, which adds insulation benefit of up to R1.0m²K/W depending on pod depth typically dictated by ground conditions.

Window glass

5-star: single-glazing with uncoated clear glass was almost universally adequate for compliance.

6-star: double-glazed units and / or low-e surface coatings to clear glass are typically required.

6½ star: as per 6-star.

Uncoated single glazing has a centre pane U-value of around 6W/m²K. With a low-e coating this would drop to around 3.5W/m²K. Uncoated double-glazing IGU has a U-value of around 2.5W/m²K. A low-e IGU has a U-value of around 1.7W/m² dropping to below 1.5W/m²K with argon cavity fill.

Uncoated clear single glazing can have an SHGC of around 0.8. Double-glazed low-e glazing can have an SHGC as low as 0.3. High SHGCs are generally desirable in heating dominated climates as they admit more passive solar heat gain.

In terms of thermal efficiency, glazing is typically the second-worst performing element in building envelopes (after window-frames). Uncoated clear glass is made in Australia and readily available. Soft low-e coated glass is not made in Australia. Since around 2010 it has been imported in large volumes by Australian manufacturers and distributors, firstly for the commercial sector (in response to BCA Section J 2010) but increasingly as a cost-effective measure for the residential sector as well.

Window frames

5-star: extruded aluminium frames were almost universally adequate for compliance

6-star: extruded aluminium frames are commonly adequate for compliance

6½ star: high-performance (thermally-broken aluminium, timber or uPVC) frames are sometimes needed for compliance.

In terms of thermal efficiency, aluminium window-frames are by far the worst-performing element in building envelopes.

Since the start of this decade increasing numbers of Australian window fabricators have been manufacturing thermally-improved and thermally-broken window-frames, again initially driven by commercial sector energy requirements. All major Australian residential manufacturers are seeing increasing demand for this product, partly driven by local government planning policies in the inner and interface suburbs requiring betterment over minimum statutory compliance.

The thermal performance of thermally-broken aluminium frames is very similar to that of both timber frames and uPVC frames. It is the dominant high-performance frame choice within apartment buildings for its durability and contemporary aesthetic but is typically the most expensive of the three options. Timber is more commonly used as a high-performance option for houses, whilst uPVC frames are rapidly gaining traction in the efficiency retrofit sector, where their 'chunky' frames may be deemed less of a visual drawback.

5.3.3 Housing typology and characteristics

Unsurprisingly, typologies with high ratios of external envelope to floor area tend to require higher performing external fabric than more compact and less exposed housing forms. Similarly, designs that preference high window-wall ratios will require higher performance glazing.

5.4 Incremental Costs

The costs of achieving 5-star, 6-star and 6½ star ratings as modelled for each typology, climate and orientation were assessed and calculated elementally by a designer-builder practice who have close interaction and familiarity with costing practices from installers and supply-chains as part of their normal course of business.

Averaged costing results across typologies indicate that the cost of stepping up through rating bands modelled for this exercise is less than 1% of typical purchase prices of such dwellings, and in most cases considerably less.

Summaries of this costing exercise for each typology, star band and climate zone are presented in Section 5.4.2 below.

5.4.1 Analysis

NCC Class 1

For the single-storey detached house modelled, the cost of getting from 5-star to 6-star is less than $2,000, and for achieving 6½ star is an additional $3000.

For the 2-storey townhouse with one neighbouring or party wall, the cost of getting from 5-star to 6-star was the highest band increases at just over $4,500.

A contributing factor to this relatively higher cost premium over detached single-storey housing is the higher ratio of façade to floor area in multi-storey townhouses, which tend to have more compact rooms than single-story house. Mid-terrace townhouses would have an additional neighbouring party wall and would therefore show smaller cost premiums.

For houses it is observed in both cases that dominant impact on cost increase occurs when the majority of glazing in the dwelling needs to go from single-glazing to double-glazing. Incorporation of low-e glass into double-glazing has a lesser effect.

Following NatHERS modelling outcomes, cost differences between climate zones were not significant. Housing built far from Melbourne often attracts higher cost rates due to increased transport costs of materials and specialist labour however this is not considered likely to have a bearing on premiums relative to overall cost of construction, which is subject to similar constraints, but should be more than offset by lower cost of land.

Apartments (Class 2)

The cost of improved ratings for the apartments modelled is consistently well below $1,000. This supports general industry experience that it is easier to procure high NatHERS ratings for apartments than for housing. This is despite the fact that apartments are commonly built to greater heights than houses in more densely developed locations, and therefore experience greater design pressure to maximise window-wall ratios in order to maximise views and daylight amenity.

On the basis of standards requiring comparable compliance effort across housing typologies, it may therefore be reasonable to set higher NatHERS compliance ratings for apartments than houses. An anomaly of current code requirements for apartments is that they are only required to achieve a 6-star performance *on average* (BCA Vol 2 J0.2(a)). New apartment developments are almost entirely purchased before construction and therefore it is largely a matter of luck whether a purchaser gains a 5-star or 7-star apartment for example, yet the consequences for the lifetime energy running costs will be very large. Eliminating the minimum individual apartment rating concession would have little effect on purchase prices and eliminates the risk to consumers of purchasing apartments that have relatively poor energy performance.

Class 1 vs Class 2 'townhouse' classification

It should be noted that the townhouse style modelled is the semi-detached duplex street-facing kind, typically built on subdivided existing housing blocks across Melbourne's extensive middle suburbs in interface councils. The BCA classifies these as Class 1 townhouses.

Larger, terraced developments are sometimes marketed as 'townhouses', but will be classified as Class 2 dwellings (apartments) when they are built over a common basement car-park. The BCA rating concession outlined above for Class 2 apartments only needing to achieve 6 stars on average across the development therefore applies, whilst the BADS cooling caps requirement do not apply. However, Class 2 'townhouses' are not covered by the Victoria variation to the NCC and are therefore not required to incorporate an individual 2,000 kl rainwater tank or solar hot water system.

5.4.2 Detached single-storey house cost tables

Single storey house		TULLAMARINE				BALLARAT				MOORABIN			
5-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	167.50	2.5	$30,372	1.5	$30,032	2.5	$30,372	2	$30,233	2	$30,233	1.5	$30,032
slab	241.80	0	$33,852	0	$33,852	0	$33,852	0	$33,852	0	$33,852	0	$33,852
roof	195.50	5	$32,672	4	$32,617	5	$32,672	3.5	$32,447	5	$32,672	5	$32,672
windows	43.75		$17,302		$17,302		$17,302		$17,302		$17,302		$17,302
TOTAL COST		$114,199		$113,804		$114,199		$113,835		$114,060		$113,859	
AVERAGE COST		$114,001				$114,017				$113,959			

Single storey house		TULLAMARINE				BALLARAT				MOORABIN			
6-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	167.50	2.5	$30,372	2.5	$30,372	2.5	$30,372	2.5	$30,372	2.5	$30,372	2.5	$30,372
waffle pod	241.80	0.75	$33,852	0.75	$33,852	0.75	$33,852	0.75	$33,852	0.75	$33,852	0.75	$33,852
roof	195.50	5	$32,672	6	$33,092	6	$33,092	6	$33,092	5	$32,672	6	$33,092
windows	43.75		$19,672		$17,765		$19,210		$18,256		$19,210		$17,302
TOTAL COST		$116,569		$115,081		$116,526		$115,573		$116,106		$114,619	
AVERAGE COST		$115,825				$116,050				$115,362			

Single storey house		TULLAMARINE				BALLARAT				MOORABIN			
6½ star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	167.50	2.5	$30,372	2.5	$30,372	2.5	$30,372	2.5	$30,372	2.5	$30,372	2.5	$30,372
waffle pod	241.80	0.75	$33,852	0.75	$33,852	0.75	$33,852	0.75	$33,852	0.75	$33,852	0.75	$33,852
roof	195.50	6	$33,092	5	$32,672	6	$33,092	6	$33,092	6	$33,092	6	$33,092
windows	43.75		$21,959		$22,010		$21,806		$22,010		$22,010		$19,250
TOTAL COST		$119,275		$118,907		$119,123		$119,327		$119,327		$116,566	
AVERAGE COST		$119,091				$119,225				$117,947			

		TULLAMARINE	BALLARAT	MOORABIN
5-star to 6-star cost comparison	5-star rating	$114,001	$114,017	$113,959
	6-star rating	$115,825	$116,050	$115,362
	Cost Increase	$1,824	$2,033	$1,403
6-star to 6½ star cost comparison	6-star rating	$115,825	$116,050	$115,362
	6½ star rating	$119,091	$119,225	$117,947
	Cost Increase	$3,266	$3,175	$2,584

5.4.3 Semi-detached double-storey townhouse cost tables

Town House		TULLAMARINE				BALLARAT				MOORABIN			
5-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	219.20		$38,523		$38,414		$38,523		$38,414		$38,523		$38,414
floor	184.90		$22,786		$21,657		$23,000		$21,657		$23,000		$21,657
roof	91.60		$15,188		$16,378		$15,188		$16,378		$15,188		$16,378
windows	45.29		$17,596		$17,596		$17,596		$17,596		$17,596		$17,596
TOTAL COST		$94,094		$94,045		$94,307		$94,045		$94,307		$94,045	
AVERAGE COST		$94,069				$94,176				$94,176			

Town House		TULLAMARINE				BALLARAT				MOORABIN			
6-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	219.20		$38,523		$38,659		$38,523		$38,659		$38,523		$38,659
floor	184.90		$22,786		$23,056		$23,000		$23,056		$22,786		$23,056
roof	91.60		$16,693		$16,693		$16,693		$16,693		$16,693		$16,693
windows	45.29		$21,747		$19,327		$21,747		$19,327		$21,747		$19,327
TOTAL COST		$99,749		$97,734		$99,963		$97,734		$99,749		$97,734	
AVERAGE COST		$98,742				$98,849				$98,742			

Town House		TULLAMARINE				BALLARAT				MOORABIN			
6½ star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	219.20		$38,659		$38,659		$38,659		$38,659		$38,659		$38,659
floor	184.90		$23,056		$23,056		$23,056		$23,056		$23,056		$23,056
roof	91.60		$16,762		$16,762		$16,762		$16,762		$16,762		$16,762
windows	45.29		$21,557		$20,816		$21,557		$20,816		$21,489		$20,816
TOTAL COST		$100,034		$99,294		$100,034		$99,294		$99,967		$99,294	
AVERAGE COST		$99,664				$99,664				$99,630			

5-star to 6-star cost comparison	5-star rating	$94,069	$94,176	$94,176
	6-star rating	$98,742	$98,849	$98,742
	Cost Increase	$4,673	$4,673	$4,566
6-star to 6½ star cost comparison	6-star rating	$98,742	$98,849	$98,742
	6½ star rating	$99,664	$99,664	$99,630
	Cost Increase	$922	$815	$888

5.4.4 2-bedroom apartment cost tables – mid-level, mid-run

Middle Apartment		TULLAMARINE				BALLARAT				MOORABIN			
5-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	158.00		$16,269		$16,269		$16,269		$16,269		$16,269		$16,679
floor	69.70		$11,152		$11,152		$11,152		$11,152		$11,152		$11,152
roof	69.70		$11,152		$11,152		$11,152		$11,152		$11,152		$11,152
windows	19.98		$15,157		$15,157		$15,157		$15,157		$15,157		$15,157
TOTAL COST		$53,729		$53,729		$53,729		$53,729		$53,729		$54,139	
AVERAGE COST		$53,729				$53,729				$53,934			

Middle Apartment		TULLAMARINE				BALLARAT				MOORABIN			
6-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	158.00		$16,679		$16,679		$16,679		$16,679		$16,679		$16,679
floor	69.70		$11,152		$11,152		$11,152		$11,152		$11,152		$11,152
roof	69.70		$11,152		$11,152		$11,152		$11,152		$11,152		$11,152
windows	19.98		$15,157		$15,249		$15,157		$15,340		$15,157		$15,340
TOTAL COST		$54,139		$54,231		$54,139		$54,323		$54,139		$54,323	
AVERAGE COST		$54,185				$54,231				$54,231			

Middle Apartment		TULLAMARINE				BALLARAT				MOORABIN			
6½ star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH			NORTH		SOUTH
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	158.00		$16,679		$16,679		$16,679		$16,679		$16,679		$16,679
floor	69.70		$11,152		$11,152		$11,152		$11,152		$11,152		$11,152
roof	69.70		$11,152		$11,152		$11,152		$11,152		$11,152		$11,152
windows	19.98		$15,375		$15,533		$15,502		$15,533		$15,502		$15,579
TOTAL COST		$54,358		$54,516		$54,485		$54,516		$54,485		$54,562	
AVERAGE COST		$54,437				$54,500				$54,523			

5-star to 6-star cost comparison	5-star rating	$53,729	$53,729	$53,934
	6-star rating	$54,185	$54,231	$54,231
	Cost Increase	$456	$502	$297
6-star to 6½ star cost comparison	6-star rating	$54,185	$54,231	$54,231
	6½ star rating	$54,437	$54,500	$54,523
	Cost Increase	$252	$269	$292

5.4.5 2-bedroom apartment cost tables – mid-level, corner

Corner Apartment		TULLAMARINE				BALLARAT				MOORABIN			
5-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	162.00		$16,894		$16,894		$16,894		$16,894		$16,894		$16,894
floor	73.10		$11,696		$11,696		$11,696		$11,696		$11,696		$11,696
roof	73.10		$11,696		$11,696		$11,696		$11,696		$11,696		$11,696
windows	31.84		$22,092		$22,573		$22,143		$22,501		$22,092		$22,410
TOTAL COST		$62,378		$62,858		$62,429		$62,787		$62,378		$62,695	
AVERAGE COST		$62,618				$62,608				$62,537			

Corner Apartment		TULLAMARINE				BALLARAT				MOORABIN			
6-star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH		NORTH		SOUTH	
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	162.00		$16,894		$16,894		$16,894		$16,894		$16,894		$16,894
floor	73.10		$11,696		$11,696		$11,696		$11,696		$11,696		$11,696
roof	73.10		$11,696		$11,696		$11,696		$11,696		$11,696		$11,696
windows	31.84		$22,917		$23,693		$22,602		$22,925		$22,602		$22,944
TOTAL COST		$63,203		$63,979		$62,887		$63,211		$62,887		$63,230	
AVERAGE COST		$63,591				$63,049				$63,059			

Corner Apartment		TULLAMARINE				BALLARAT				MOORABIN			
6½ star rating													
Home orientation		NORTH		SOUTH		NORTH		SOUTH			NORTH		SOUTH
Building Fabric	SQM	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost	R value	Cost
walls	162.00		$16,894		$16,894		$16,894		$16,894		$16,894		$16,894
floor	73.10		$11,696		$11,696		$11,696		$11,696		$11,696		$11,696
roof	73.10		$11,696		$11,696		$11,696		$11,696		$11,696		$11,696
windows	31.84		$22,810		$24,694		$22,734		$25,250		$22,688		$23,693
TOTAL COST		$63,096		$64,980		$63,019		$65,536		$62,974		$63,979	
AVERAGE COST		$64,038				$64,278				$63,476			

5-star to 6-star cost comparison	5-star rating	$62,618	$62,608	$62,537
	6-star rating	$63,591	$63,049	$63,059
	Cost Increase	$973	$441	$522
6-star to 6½ star cost comparison	6-star rating	$63,591	$63,049	$63,059
	6½ star rating	$64,038	$64,278	$63,476
	Cost Increase	$447	$1,228	$418

6. Results and Analysis

6.1 Energy Performance Requirements

6.1.1 Housing Stock Composition and Evolution

The stock model developed for this project utilises observations of the *occupied* dwelling stock by type from the Censuses in 2011 and 2016, with linear interpolation in between (and projection before/after) to estimate the net stock in each year. We note that DELWP has been advised that different collection methods were used for the 2011 and 2016 Censuses, and so the results are not strictly comparable. The 2016 Census shows a drop in occupied apartments, for example, that is difficult to reconcile with other data sources. Household occupants nominate the dwelling type during the Census, and they may be unaware of the correct classification.

This data was compared with that available from the Victorian Valuer-Generals (which was complete only until the end of 2015), and we note that it aligns well with the Census values for the sum of occupied and unoccupied dwellings (in 2016), with both sources finding a total of 2.37 million dwellings in Victoria.

However, the distribution of the total dwelling stock by dwelling type appears to vary considerably between sources. For example, the 2016 Census indicates some 300,900 *occupied* semi-detached dwellings in that year and 246,000 occupied apartments. Values for total unoccupied dwellings are provided, but not by type. There were some 278,600 unoccupied dwellings in Victoria on Census night, representing 11.7% of total stock. However, the Valuer-General's data indicates a total of only 14,158 semi-detached dwellings, representing just 0.6% of the stock. Investigating this issue further, and noting that the Valuer-Generals' data is compiled for the purpose of calculating local government rates and utilises a different frame of reference than the National Construction Code's classes, it is likely that some semi-detached dwellings are being counted as apartments. For example, this source estimates there for 619,603 apartments in Victoria (end 2015), compared to the much lower value for *occupied* apartments in the 2016 Census.

These trends also needed to be reconciled with superficially-inconsistent trends in the nature of the stock change over time. For this, we make use of ABS completions data, as it provides a regular (quarterly) and consistent source on the number (and value) of dwellings completed in Victoria, including over the whole of the evaluation period.[46] Limitations associated with this source include that completions only distinguish 'houses' and 'other residential', with the latter including semi-detached Class 1 dwellings (townhouses) and Class 2 units or apartments. As noted, however, different requirements apply to these two building classes, and therefore it is necessary to estimate

[46] The latest data is current to March 2018, and therefore not a complete basis for estimating the 2017-18 financial year. Completions in this year and the current financial year, FY2018-19, are therefore estimated by assuming the same number of completions as FY2017.

the split of completions by dwelling class. The annual completions data is shown in Figure 6. It may be noted that:

- There was a sharp spike and then fall in 'other residential' completions in FY2008, which is likely to be related to the Global Financial Crisis of this period
- While there has been significant growth in total completions, this growth is almost all in 'other residential' dwellings; Class 1 house completions have remained broadly constant over this period.
- Alterations, additions and conversions (from one class to another) are very much smaller in number (around 600 per year, on average). However, we note that the average *value* of these completions is over $3.5 million, and up to $6.8 million in FY2016, suggesting that they may be conversions of smaller residential dwellings to larger apartments or townhouse developments.[47]

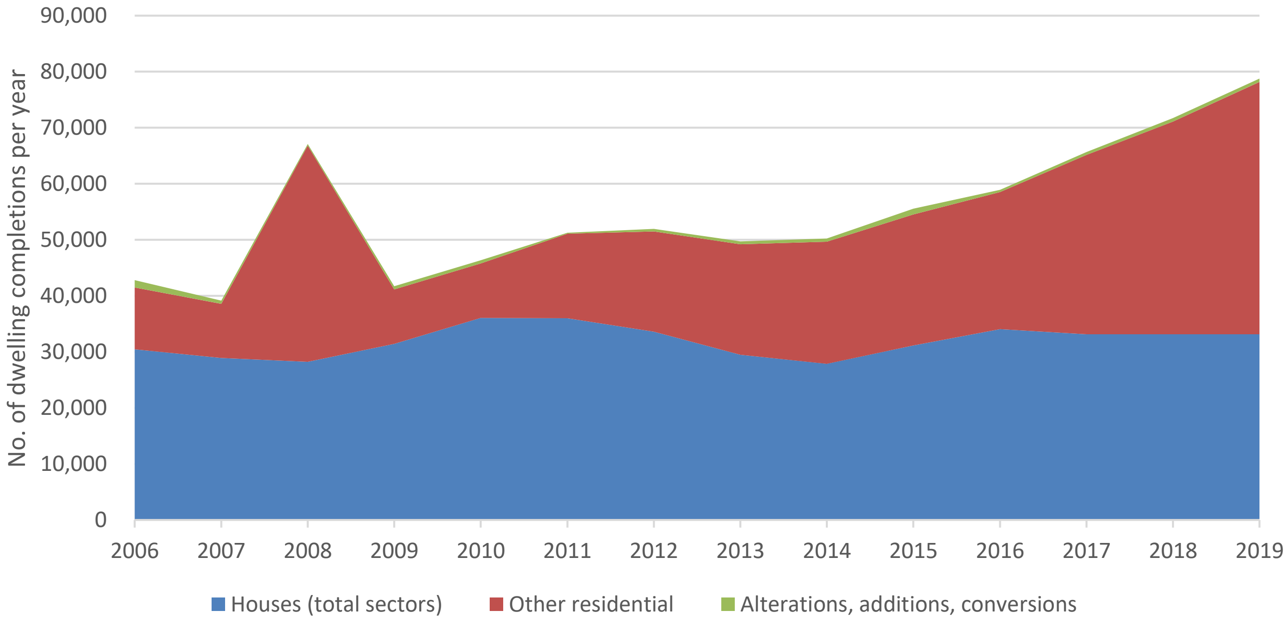


Figure 6: Annual Dwelling Completions Victoria, FY2006 – FY2019, by Type

While the Valuer-Generals' data by construction year agrees broadly with the ABS observations of *total* completions annually, it shows a much higher number of house constructions than the ABS; much lower semi-detached completions (only 100 – 300 per year); and somewhat lower apartment completions. It is likely that a percentage of the construction marked as houses is instead townhouses and apartments.

[47] Derived from ABS, 8752.0 Building Activity, Australia, TABLE 42. Value of Building Work by Sector, Victoria: Original.

The Census data over time – which distinguishes occupied dwellings by type – suggests that there has been rapid growth in occupied townhouses over the 2011 – 2016 period, and a significant decline in occupied apartments: see Figure 7. The data for townhouses and apartments appears to conflict with ABS completions – for example, the falling number of occupied apartments over time contrasts sharply with the rapid growth in 'other residential' completions, as well as observed trends in the Victorian market, where apartment development has been rapid in recent years.

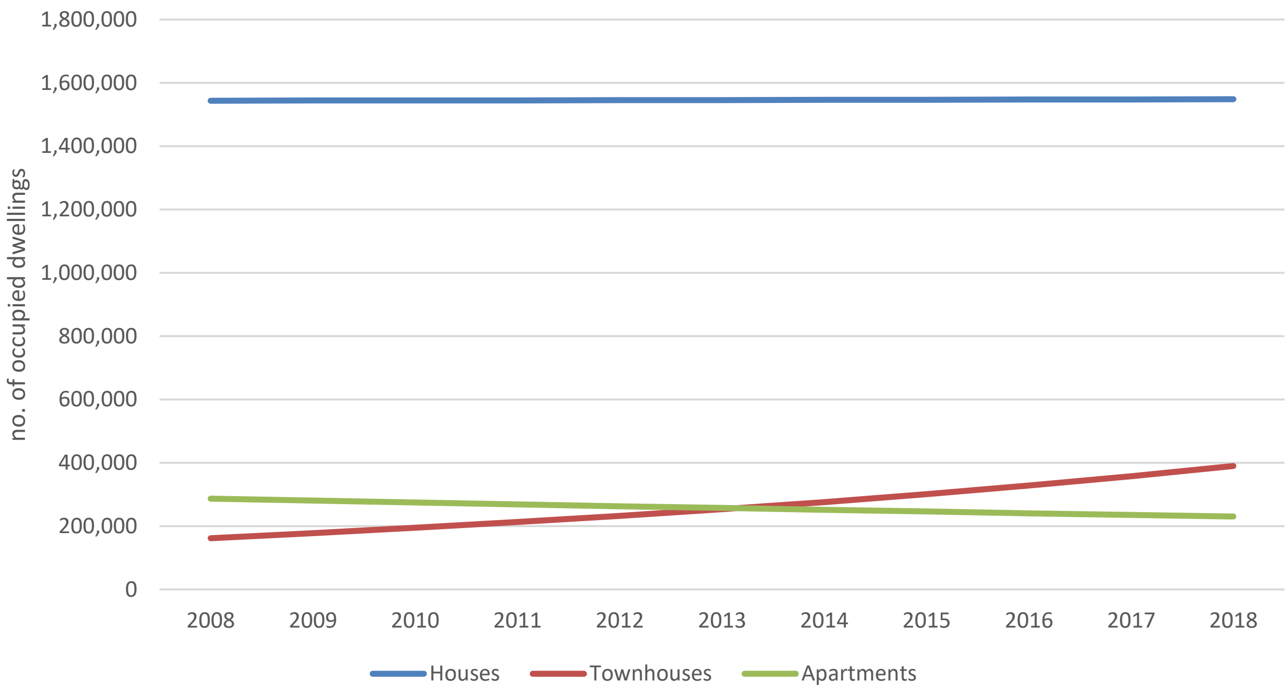


Figure 7: Number of Occupied Dwellings by Type, Victoria

It is likely that the reconciliation of these observations lies in the distribution of the *unoccupied* housing stock. For example, we can balance the completions data with Census trends as follows:

1. Applying the Census observations of shares of occupied house and semi-detached dwellings to the 'other residential' completions data, with approximately 25% of other residential completions assumed to be semi-detached and 75% apartments.[48]
2. Applying differential rates for the unoccupied share of houses, semi-detached and apartment dwellings. In particularly, we assume that unoccupied houses have remained fairly constant at around 9% - 10% of the total stock; semi-detached vacancy rates have fallen slightly over time (from an estimate of 12% in FY2020 to 7% by FY 2019); while apartment vacancy rates are higher and rising over time (eg, from an estimate of 20% in FY2010 to 28% in FY2019).

[48] Note that the ABS completions data include 'conversions' which, as noted, are likely to be dominated by apartment-style buildings.

The total number of new dwellings (and refurbishments, alterations and additions – see below) built to Code each year is estimated on this basis to have risen from around 62,000 in FY2012 to around 89,000 in FY2019. These values include allowances for the share of new dwellings and renovations estimated to have used NatHERS as a Code compliance pathway. They are higher than annual completions because of the allowance for alterations, additions and major refurbishments, which are considered further below. Overall, some 563,000 dwellings are estimated to have been built (or renovated) to current Code standards since their introduction in FY2012 and the end of FY2019. This is an important indicator of the potential 'reach' or impact of the 6-star standard. As discussed further below, some of these dwellings (and more of the alterations and additions) will have demonstrated compliance with the Code's energy performance requirements via the DTS path. However, the majority of new dwellings in Victoria appear to have selected the 6-star compliance pathway.

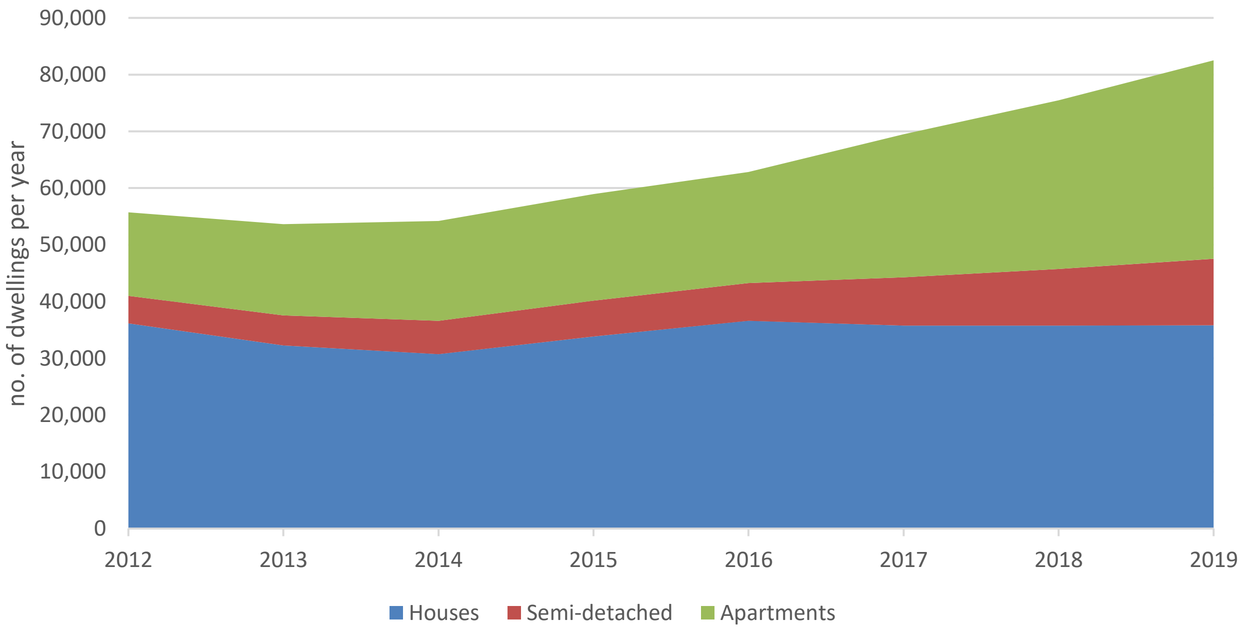


Figure 8: Estimated Number of New Dwelling Completions (including alterations, additions, refurbishments) to Code Per Year, Victoria

The continued growth from FY 2016 reflects robust growth in completions in the historical period, and this is projected to continue until the end of FY2019. We note that there has been speculation in the media for many years about whether or when the 'apartment boom' in Melbourne and other cities might end. However, even if there were to be a slow-down in construction over the balance of this year, this would only slightly reduce both benefits and costs modelled in this study, without changing the overall benefit cost ratios.

Floor Area Totals

ABS completions data are published in terms of the volume (no. of projects) and value of projects completed in a quarter. The floor area of the completions is not published. However, this data can be purchased from the ABS on special order, but again separated only into houses and 'other residential'. We apply the 'houses' values to Class 1ais and the same average floor area estimates to Class 1aiis and Class 2s. Noting that changes in the average size of new completions has not varied greatly over time (new houses have become slightly smaller), we assume the same average sizes apply in the latter years of the analysis, not covered in the special order data – see Figure 9.

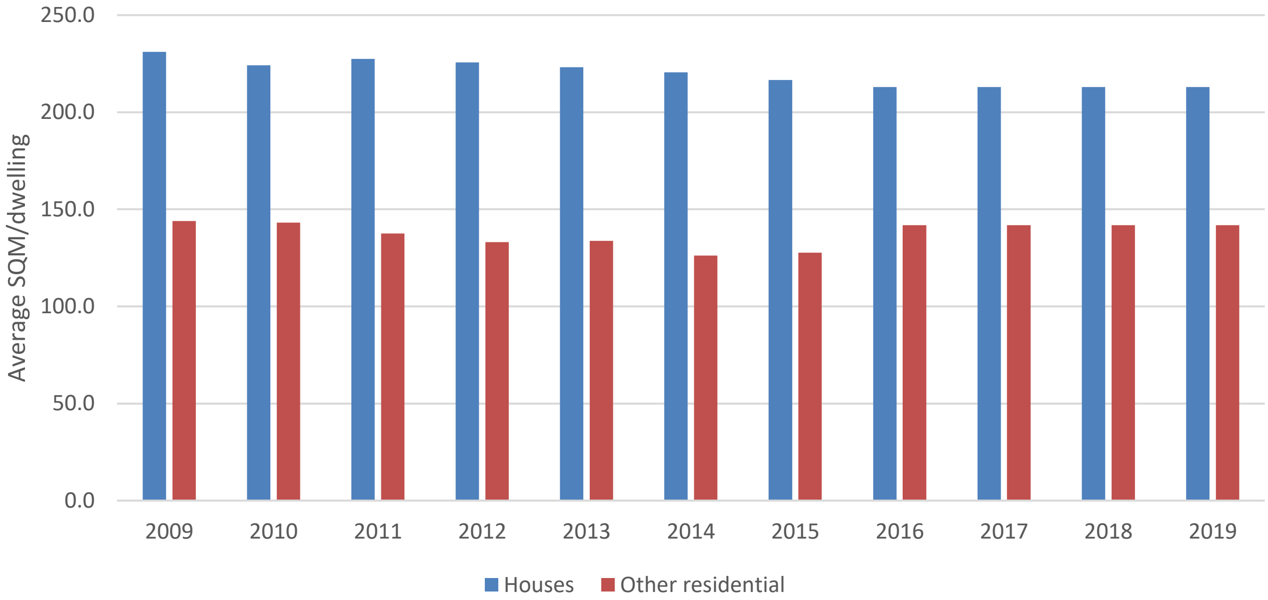


Figure 9: Average Size of New Residential Dwelling Completions – Victoria

Taking these average sizes into account, we estimate that between 9.7 million sqm (2014) and 14.2 million sqm (2019) of new floor area was built or renovated to Code per year over the evaluation period, or some 92.5 million sqm in total over this period. The relatively faster growth of apartments and semi-detached townhouses than of houses is again evident. It should be noted that ABS floor area data is based on the external dimensions of the dwelling, and therefore includes garages and internal wall space. Our modelling discounts the ABS gross floor area data by 15% to allow for unconditioned, net (or usable) floor area.[49]

[49] RMIT, *Development of Representative Dwelling Designs for Technical and Policy Purposes*, 2013, p. 16. ABS floor area data is measured from the exterior dimensions of the dwelling, and thus includes wall cavities in addition to unconditioned areas such as garages and laundries.

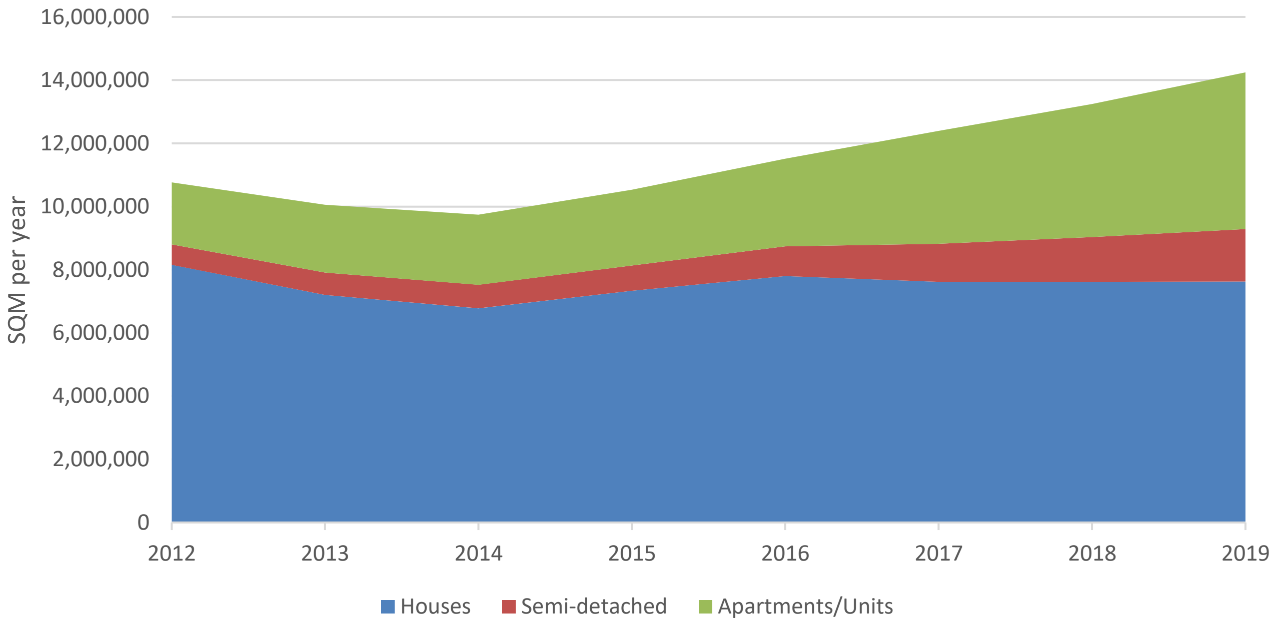


Figure 10: Estimated Floor Area of New Dwelling Work (including alterations, additions, refurbishments) to Code Per Year, Victoria

Alterations, Additions, Major Refurbishments

Code energy performance requirements apply – with some flexibility, as noted above – to alterations, additions and major refurbishments (ie, sufficient to trigger the 'upgrade to new standards' provision). Unfortunately, there is less transparency as to activity rates in these areas than there is for new dwellings.

ABS completions data include 'alterations and additions to existing buildings', which is resolved as a 'type of work' in the data. The number of alterations and additions is not, however, broken down by dwelling type. While the data suggests that over 3% of completions in FY2006 were alterations, additions or conversions, the average value over FY2012 – FY2017 has been 1% per year.

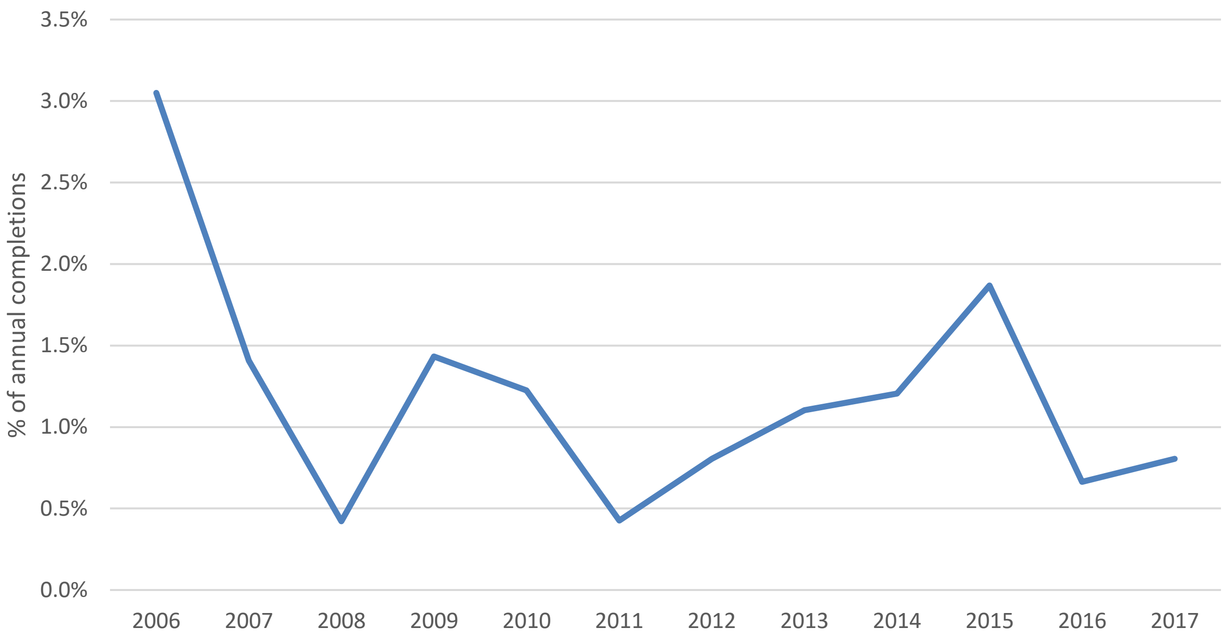


Figure 11: Annual Share of Completions that are Alterations, Additions or Conversions, Victoria

Our stock model – which, as noted, reconciles conflicting or incomplete data sources into a coherent picture of dwelling stock turnover over this period – produces the following picture of the number of dwellings by type undergoing refurbishment, alterations or additions annually – see Figure 12.

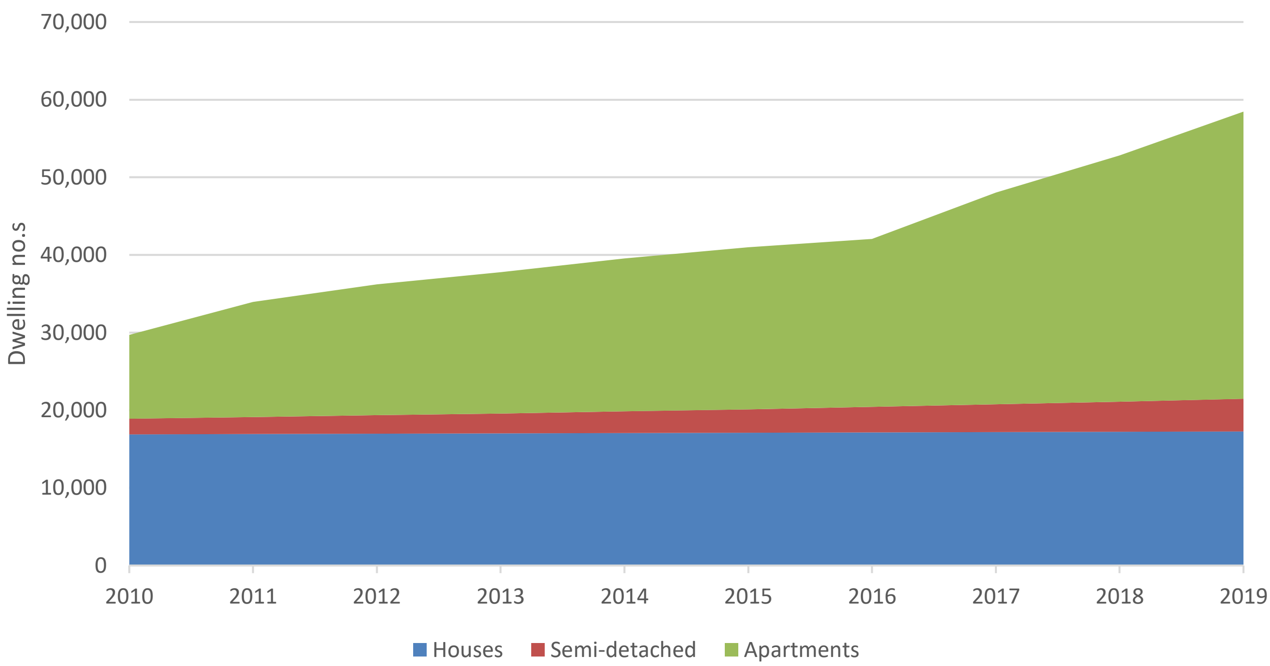


Figure 12: Annual refurbishments, alterations and additions by dwelling type

Another partial observation in this area is offered via the Valuer-Generals' data, which indicates renovation rates by construction year of around 0.2% per year, on average, although up to 0.7% per year for the oldest stock (categorised as construction year of 1899 or earlier) – seeTable 13. However, it is likely that this data does not pick up all renovations, but only 'significant renovations', including those that significantly alter the 'outward appearance' of the dwelling.[50] Also, the Valuer-Generals' data will only note that renovations detected and determined to be sufficiently material to affect the property valuation.

CONSTRUCTION YEAR	Total Dwellings	Total renovated - all times	% renovated - all times	Annual rate, >2011	Annual rate, 2004-2005	Annual rate, 2006-2010	Average annual rates
<=1899	48,956	6,988	14.3%	0.7%	0.5%	0.8%	0.7%
1900-1944	207,495	20,581	9.9%	0.6%	0.5%	0.5%	0.5%
1945-1980	898,224	43,355	4.8%	0.2%	0.3%	0.3%	0.2%
1981-1991	322,332	11,800	3.7%	0.2%	0.2%	0.2%	0.2%
1992-2003	399,713	13,328	3.3%	0.1%	0.1%	0.2%	0.1%
2004-2005	81,420	2,320	2.8%	0.1%	1.1%	0.0%	0.4%
2006-2010	214,510	5,776	2.7%	0.0%	0.0%	0.5%	0.2%
>=2011	256,017	3,189	1.2%	0.2%	0.0%	0.0%	0.1%
none/unknown	112,442	4	0.0%	0.0%	0.0%	0.0%	0.0%
Totals	**2,541,109**	**107,341**	**4.2%**	**0.2%**	**0.2%**	**0.2%**	**0.2%**

Table 13: Valuer-Generals' Data: Renovation Rates by Year of Construction

A final partial observation is offered by the BESS data, noting that this only covers the approximately 2-year period from mid-2016 to mid-2018 in the 24 participating LGAs. This data shows that only 0.12% of the dwelling projects over that period, and 0.11% of the floor area, are identified as extensions (all single dwelling extensions).

Overall then, we do not have clear guidance on the rate of alterations, additions and major refurbishments in the Victorian housing stock, sufficient to trigger the application of new building energy performance requirements. Statistically, a renovation rate of 2% of the stock per year would imply that a house would undergo a major renovation, on average, once every 50 years, while a rate of 1% per year implies a major renovation once every 100 years. While the latter rate appears low,

[50] Valuer General Victoria *2016 Revaluation Best Practice Guideline: data specifications*, 2016.

it is nevertheless higher than indicated by the ABS completions or the Valuer-Generals' data. We adopt this rate as an assumption in our stock model.

As a general comment on the housing stock data uncertainties, we found *significant* differences between the different official data sources and difficulty in reconciling them into a coherent overall picture. As a result, confidence in key stock change parameters is therefore low. While an investigation of the underlying causes for this is beyond the scope of the current evaluation, it would appear to merit further analysis in future.

Compliance Pathway Estimates

Figure 13 was prepared by CSIRO, which manages the NatHERS Portal. This data source – which includes data provided to CSIRO by Sustainability Victoria – tracks NatHERS Certificates by state and dwelling type. It has been used here to compare the rate of Certificate issuance with ABS approvals data by State. The data shows that in Victoria at least, the approvals rate and certificate rate are a very close match, indicating that most new buildings in Victoria use the NatHERS compliance pathway. This accords with our industry consultations. As shown, both series are volatile, and certificates are likely to lag approvals by at least a year – therefore the exact percentage of dwelling completions that use the NatHERS pathway is not known, but it is likely to be close to 100% in Victoria.

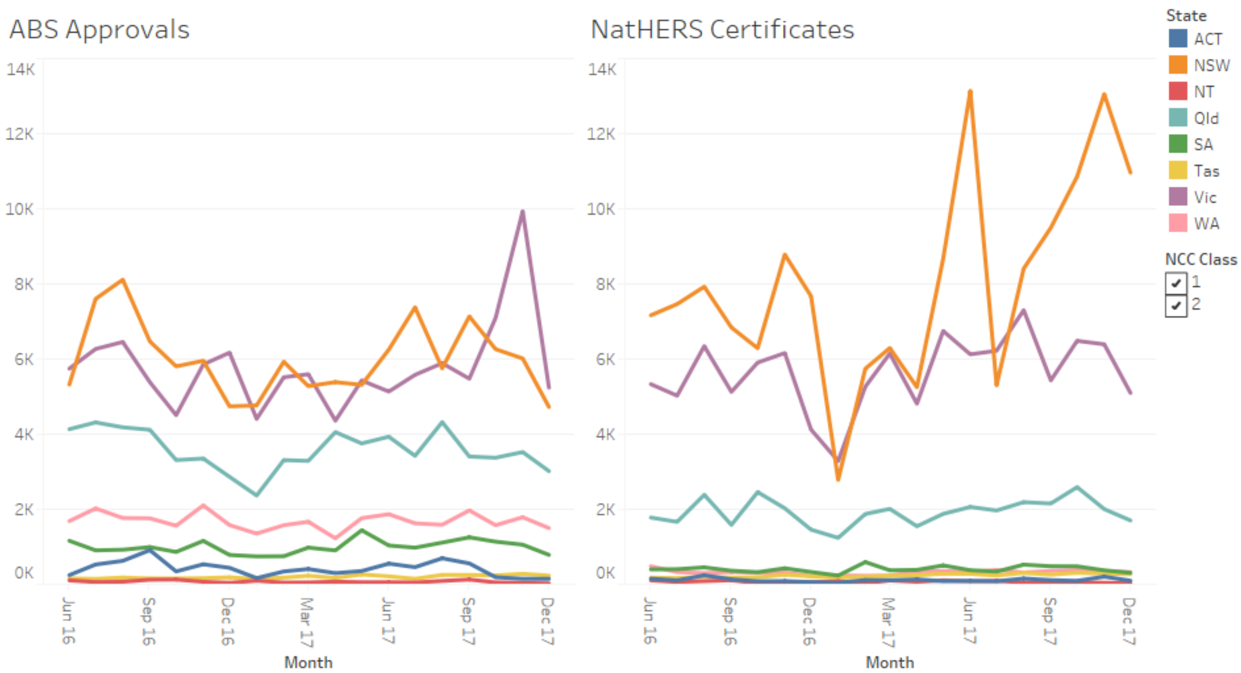


Figure 13: NatHERS Ratings vs ABS Approvals by State

Another perspective on this is offered by Figure 14, which shows that there is a close correlation between NatHERS Certificates and ABS completions for dwellings in Victoria. We also show the fitted curve used in our stock model, which includes the allowance for alterations, additions and major refurbishments.

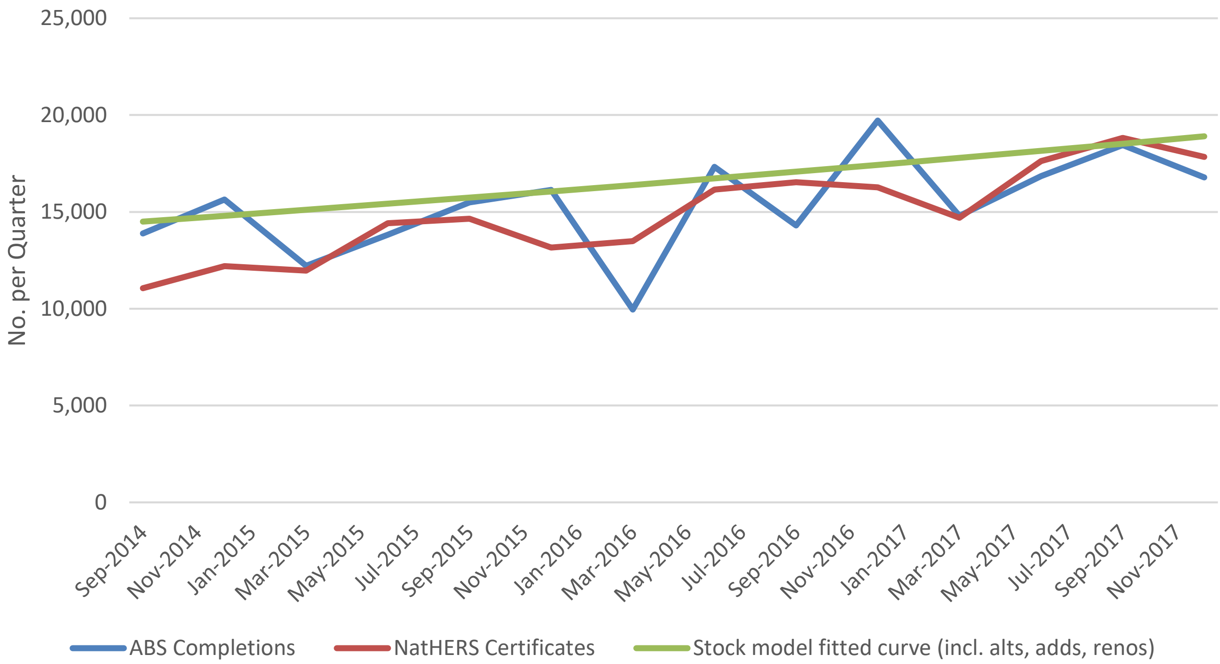


Figure 14: ABS Completions, NatHERS Certificates (per quarter) and Stock Model Fitted Curve, All Dwellings, Victoria

Data from the NatHERS Portal reviewed in Section 6.1.2 suggests that a high percentage of alterations and extensions may be achieving compliance via DTS rather than the NatHERS pathway. This is consistent with industry consultations, which suggest that DTS is used for smaller/simpler extensions and alterations, and NatHERS ratings for larger or more complex ones. For this study, we estimate 95% of Class 1 new dwelling completions use the NatHERS compliance path, and 50% of renovations and additions. For Class 2 dwellings, we assume 100% use the NatHERS compliance path and 75% of renovations and additions. We are not aware of any definitive data source that would establish these values with greater precision.

Activity by Climate Zone

A NatHERS 6-star rating has a unique meaning, in terms of maximum annual thermal load limits, for each of 69 climate zones across Australia. Of these, 10 'principal' climate zones are represented in Victoria, although energy assessors may select from secondary or even tertiary climate zones (in some cases) in situations where they believe the principal one is not appropriate. This may occur near to the border between one climate zone and another, for example. Due essentially to differing degrees of climate severity, there are significantly higher or lower allowed thermal loads in different Victorian climate zones at given star rating bands. For reference, Table 14 shows the allowed thermal loads for a range of star bands in the relevant NatHERS climate zones, while Figure 15 provides a map of the NatHERS climate zone in and near Victoria.

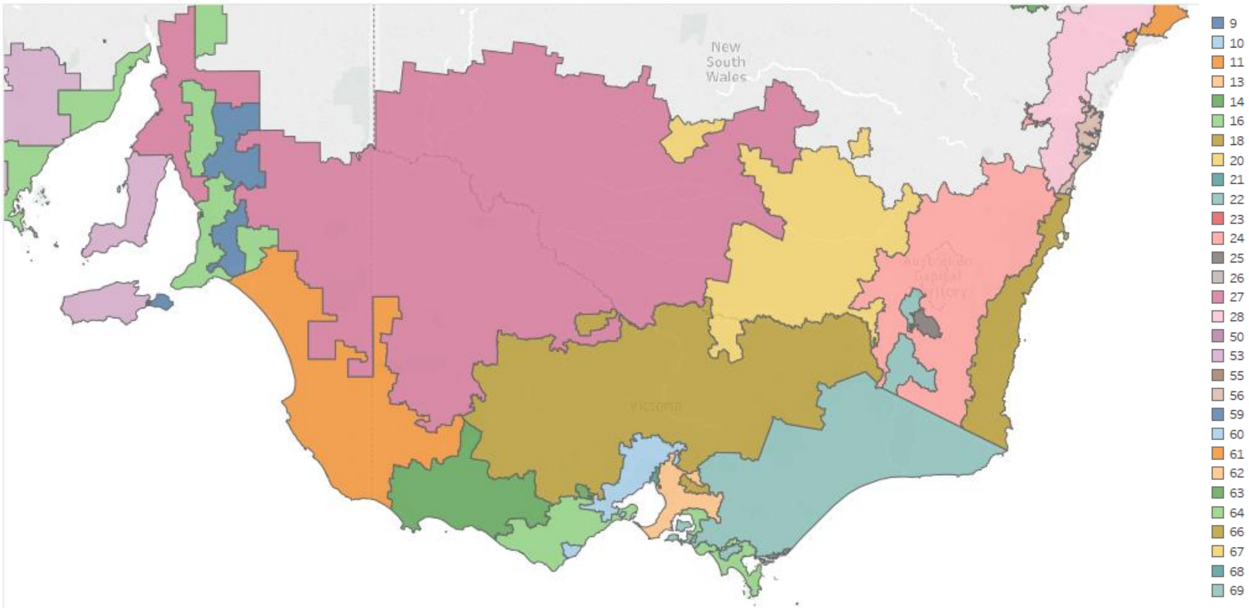


Figure 15: NatHERS Climate Zones/Numbers in and near Victoria

Climate Zone Number	Climate Zone Name	5-star MJ/m².a	5.5-star MJ/m².a	6-star MJ/m².a	6.5-star MJ/m².a
21	Melbourne	149	131	114	98
22	East Sale	175	153	133	115
25	Cabramurra	454	401	352	303
27	Mildura	143	126	110	96
60	Tullamarine	182	158	138	118
61	Mt Gambier	189	165	144	124
62	Moorabbin	165	144	125	108
63	Warrnambool	197	173	151	130
64	Cape Otway	168	146	127	109
66	Ballarat	257	225	197	169

Table 14: Victoria's Principal Climate Zones and Annual Thermal Load Caps, Selected Star Ratings

The different thermal allowances by climate zone, together with the availability of ratings data by climate zone, mean that the ideal spatial unit for conducting this evaluation is the climate zone. However, ABS completions are tracked only by State. The Valuer-Generals' data on the Victorian housing stock is, however, available by local government area (LGA), and each local government area can be assigned to a primary NatHERS climate zone. Therefore, we first summarised the number (and then percentage shares) of houses, semi-detached dwellings and apartments for each LGA, recalling this data is current to end 2015, and noting the limitations above regarding the distribution of dwelling types in this data set. Second, we allocated each Victorian LGA to its principal NatHERS climate zone. Third, we summarised the number (and then percentage shares) of dwellings by type by NatHERS climate zone. Finally, this distribution of dwellings is applied to the estimate of floor area built to Code annually, as described above. The implicit assumption is that the distribution of new dwelling activity is broadly proportionate to the distribution of the existing dwelling stock. The actual spatial distribution of new dwellings may be changing, due to the concentration of building activity in certain areas. However, this is not likely to have a significant impact on the findings of this study.

The distribution of dwelling types in Victoria varies noticeably both by climate zone and LGA. As an indication, the 2015 distribution by dwelling type is shown below in Figure 16 to Figure 18. Houses are weighted towards the Moorabbin and Tullamarine climate zones; with semi-detached weighted most heavily towards Moorabbin, and apartments weighted towards Moorabbin, Melbourne and then Tullamarine.

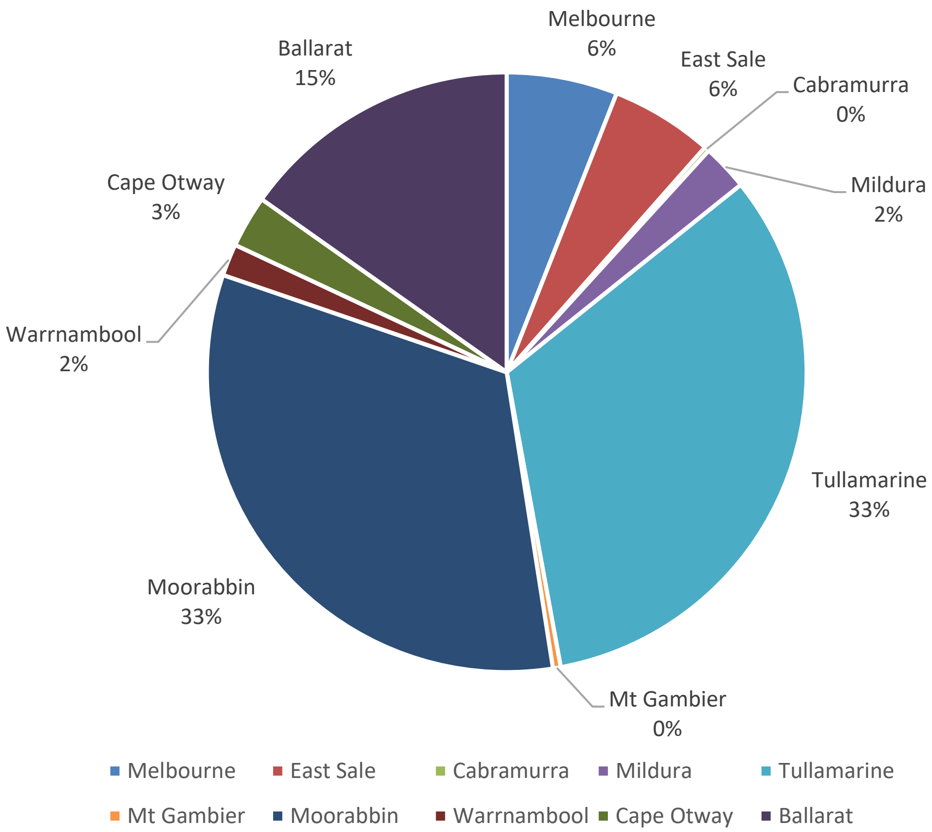


Figure 16: Distribution of Houses by Climate Zone, Victoria, 2015

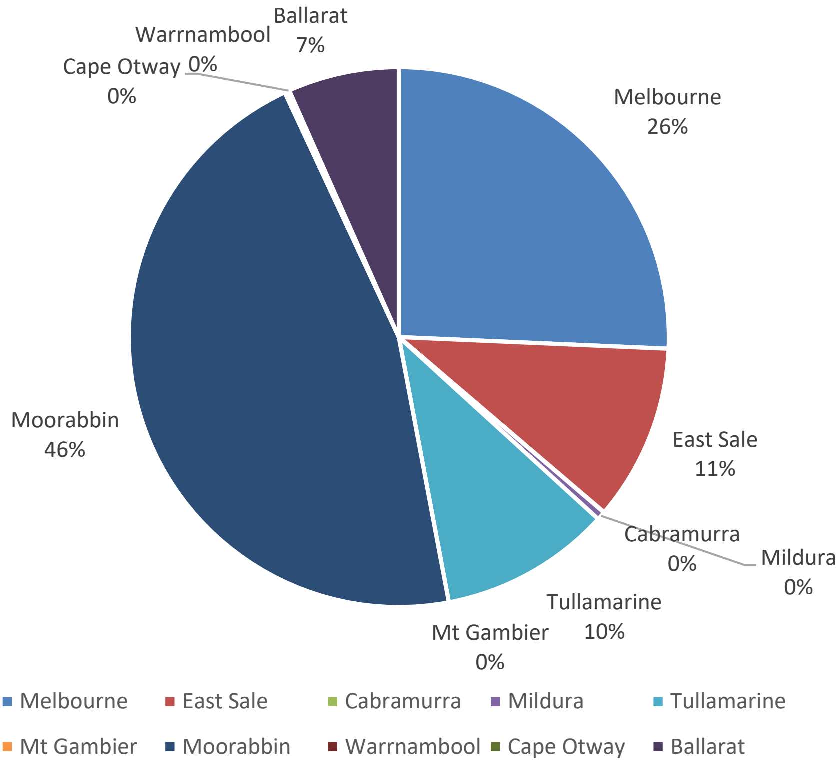


Figure 17: Distribution of Townhouses by Climate Zone, Victoria, 2015

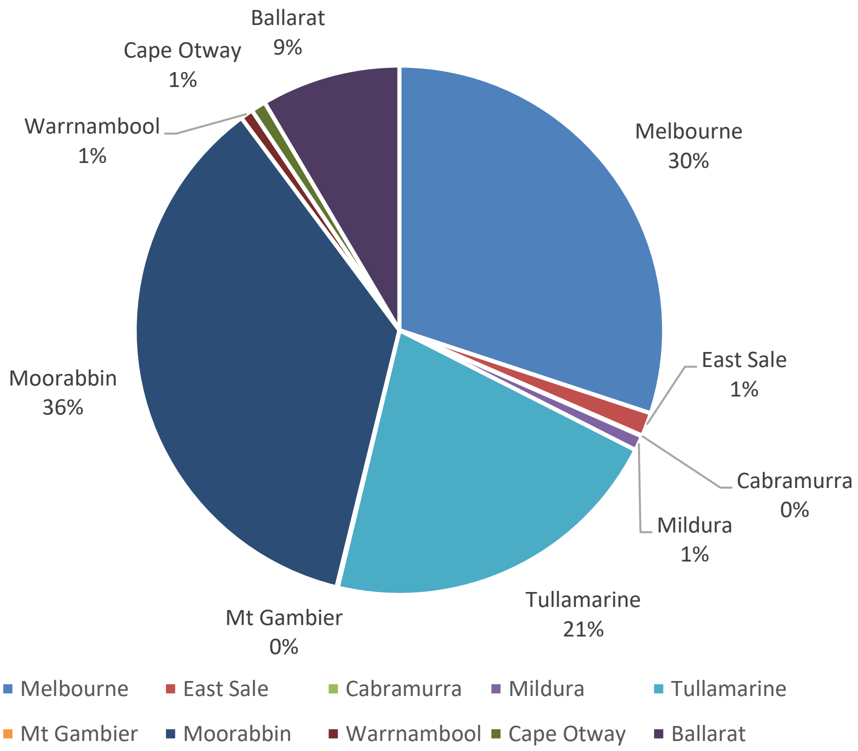


Figure 18: Distribution of Apartments by Climate Zone, Victoria, 2015

6.1.2 Energy Performance Outcomes

The next key element in assessing the outcomes of the 6-star standard is to determine, so far as possible, what the actual outcomes were.

It is not necessary to capture data on the actual energy use of all of the more than 560,000 dwellings built to this standard, in order to address this question. The 6-star standard does not regulate the whole energy performance or consumption of dwellings. Nor does it regulate the occupancy pattern of dwellings, the density of plug-in appliances, energy use behaviours, the choice of space conditioning equipment, nor less the actual climate from time to time – yet all these factors have a large influence on the actual energy consumption of dwellings, independently of its star rating. Rather, and as set out in Section 1.2, the 6-star standard seeks to regulate the annual thermal load of the thermal envelope of dwellings and, through that, the energy used for space heating and cooling purposes. For the most part, this is indicated by the star rating. Two qualifiers on this observation are:

- The extent to which dwellings ‘as built’ comply with the ‘as-designed’ rating and with the 6-star standard
- The accuracy of the star rating.

On the first question, the Victorian Building Authority is currently undertaking a large number of audits with the aim of verifying the extent of as-built compliance *inter alia*. Results are not yet available. On the second question, a national study conducted in 2014 gave some cause for concern. A sample of 314 energy assessors (out of an estimated total of 1816 assessors) agreed to participate in an evaluation found that only 37% of assessments were within 0.25-stars of the correct rating, while 64% of assessors had an error greater than this margin. The stated purpose of this study was to create a national benchmark by measuring the accuracy of NatHERS assessments. [51] Results for Victoria indicated that, on average, assessors were within +/- 8.1% of the correct answer, as compared to +/- 4.8% for Australia as a whole. Unaccredited assessors – which are permitted in Victoria – were on average only within +/- 20.5% of the correct answer. [52]

In terms of this evaluation, the degree of compliance and the performance of assessors are not issues that are attributable to the 6-star standard. Both issues would have been important if the standard had remained at 5-star, and both issues are being addressed through processes that are independent of the question of the level of the energy performance standard in Victoria.

Our key data source on Victorian dwelling ratings is the CSIRO NatHERS Portal data. This data – for which the total sample is 256,633 certified ratings – shows the number of ratings and the star rating results (in 0.1 star ‘bins’) for Class 1, 2 and 4 dwellings. The data set represents the ratings certificates values for FirstRate 5 and AccuRate over the period from 2014 – 2018. However, the data is not fully allocated by class for 2014 and 2015, as this data field was not always collected

[51] Floyd Energy, *NatHERS Benchmark Study*, February 2014, p. 6.
[52] Ibid, p. 22.

under FirstRate5 ratings at the time. As the data relates to calendar years, 2018 was incomplete at the time provided and therefore not used in this analysis.

Since there is great deal of data in this set, it is only feasible to present some indicative samples. Figure 19, for example, shows the distribution of star ratings for new Class 1 dwellings in 2016. Note that the vertical scale is exponential. Over 86% of all ratings are 6 star, and only 1.6% of ratings are less than 6 star. That is, 98.4% of ratings are 6 star or more. It is likely that the lowest ratings were not undertaken for compliance purposes, while others may be interim ratings, subject to further design changes prior to seeking compliance.

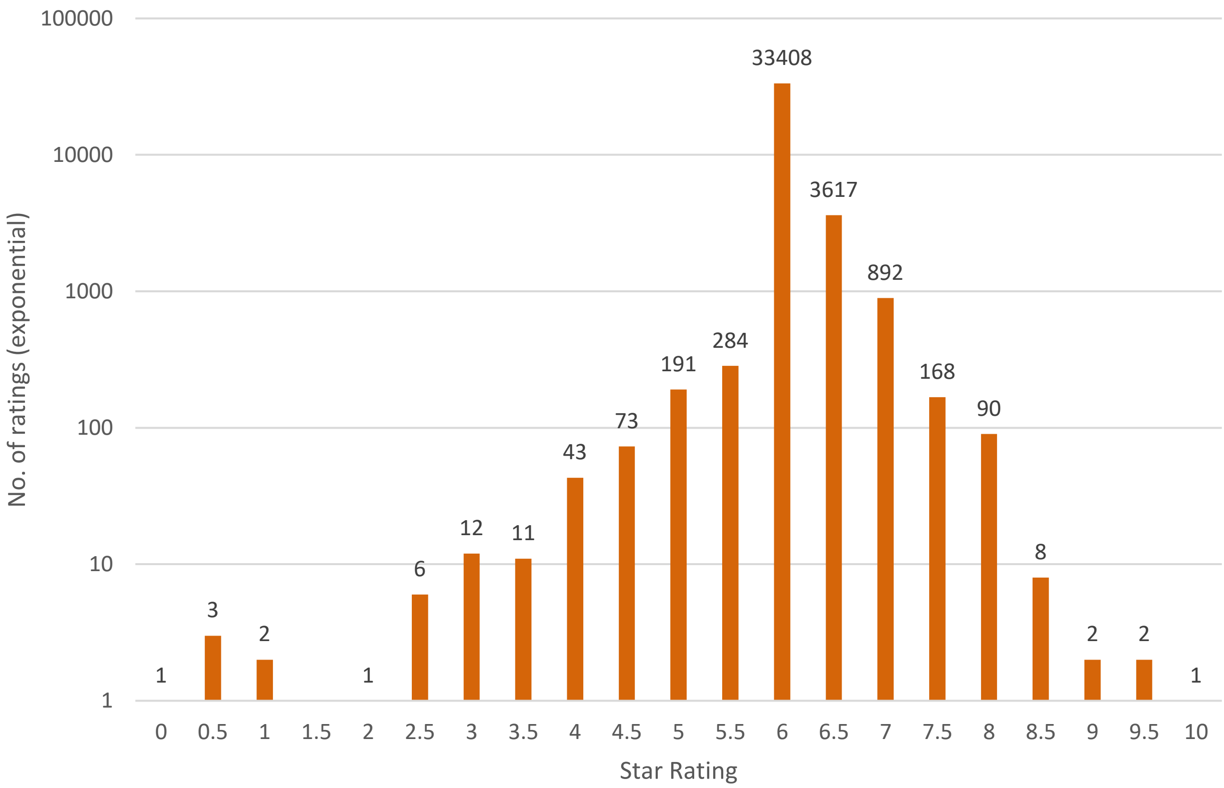


Figure 19: 2016 New Class 1 Dwelling Ratings, Victoria

Another way to envisage the overall data set is presented in Figure 20. This shows the average star ratings by dwelling type and climate zone, for 2016 and 2017, which are the years for which the data set is most complete. Note that some climate zones show no Class 2 dwelling ratings in some years.

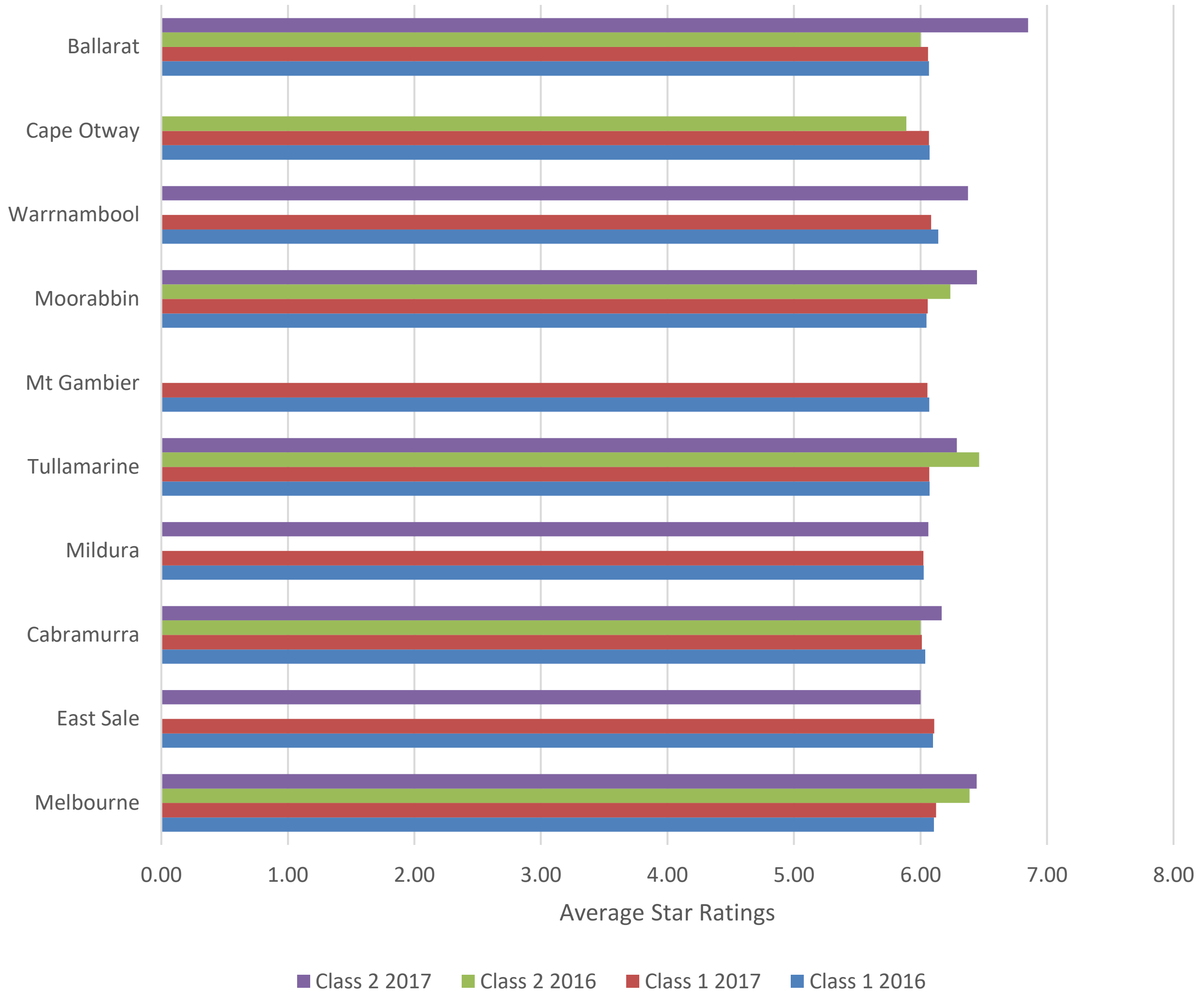


Figure 20: Average Star Ratings, 2016 and 2017, by Dwelling Class and Climate Zone

Overall, new Class 1 dwellings averaged a star rating of 6.06 in 2016 and 6.07 in 2017, while new Class 2 dwellings averaged 6.35 in 2016 and 6.43 in 2017. Some data was available for Class 1 dwellings for 2014 and 2015 as well, and for 2015 only for Class 2 dwellings. We make the simplifying assumptions that 2017 results apply also for 2018 and 2019 for both classes, while 2014 Class 1 results apply also for 2012 and 2013 for Class 1 dwellings. For Class 2 dwellings, we apply an average of the known ratings for 2015 – 2017 to represent the (unknown) outcomes in the 2012 – 2014 period – see Figure 21.

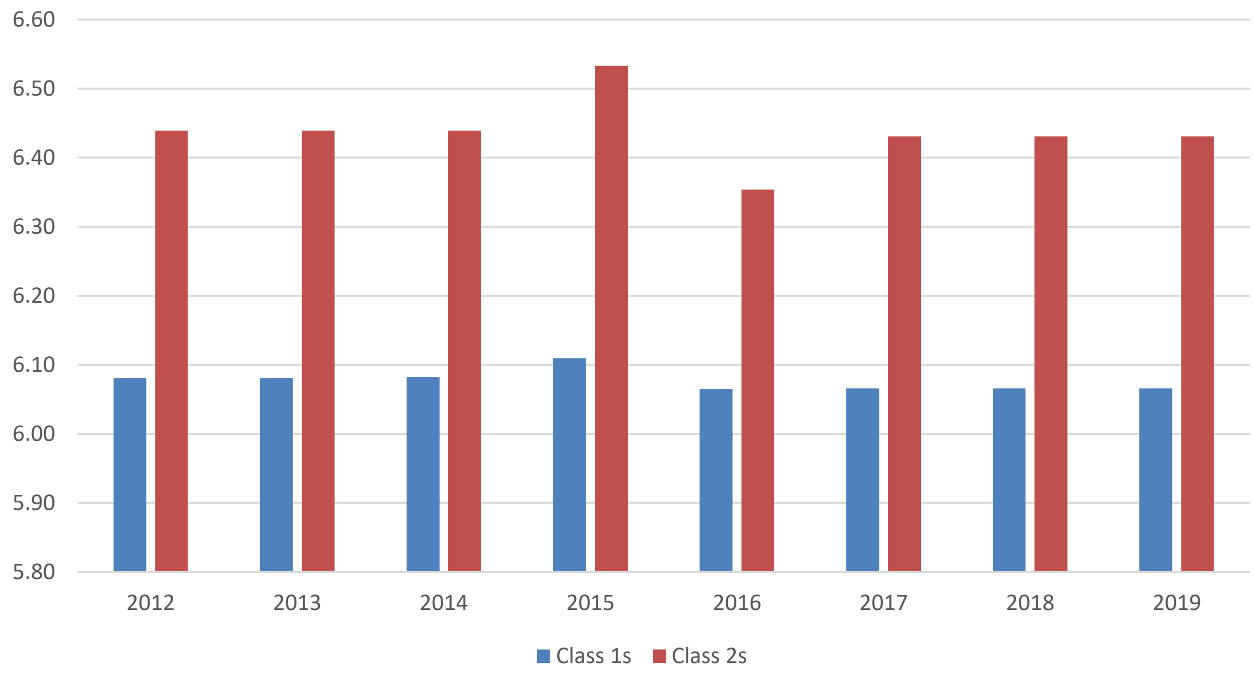


Figure 21: Modelled Distribution of NatHERS Ratings by Dwelling Type, Victoria, 2012 - 2019

A final note on this data is that it is not surprising that there are a significant number of Class 2 ratings below 6-star, given that the requirement is only that Class 2 dwellings in a development must *average* 6-star. This could mean, for example, that 50% rated above 6-star and 50% below, while still being fully compliant with the Code requirement. Despite this, the average Class 2 rating in all years (for which there is data) is well above 6-star.

For an historical evaluation, ideally we would have a more complete data set on dwelling ratings. However, ratings outcomes were not centrally reported before ~2015. As a result of these data limitations, it is not possible to comment on issues such as whether there was a material change in ratings over the study period. Also, as noted, the NatHERS data represents as-designed, rather than as-built ratings. The current VBA/DELWP study into compliance outcomes will help to shed light on the extent to which as-designed and as-built outcomes match.

New Dwelling Fuel Mix

The 6-star rating requirement is deliberately expressed in metrics that are neutral with respect to the choice of fuels and technologies that are used for space conditioning. This is a consumer choice, albeit that some minimum energy performance requirements apply to some space conditioning equipment. However, the choices actually made by Victorian households will affect the volume and value of energy savings, and also the volume of greenhouse gas emissions savings.

In total, the residential sector in Victoria is unusually skewed towards gas consumption, reflecting the heating-dominated climate, the early availability of and widespread distribution network for gas, and its relatively low price compared to electricity in particular. Figure 22 is sourced from

Australian Energy Statistics, Table F, and shows the final consumption shares for residential fuels in 2016.

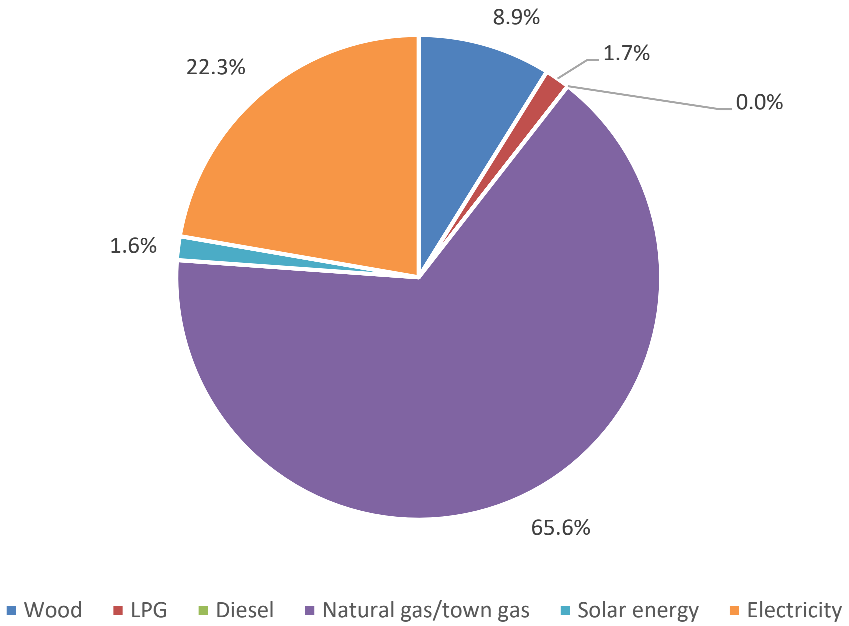


Figure 22: Residential Final Fuel Consumption Mix, 2016, Victoria (Australian Energy Statistics)

However, this overall mix does not necessarily indicate the fuel/technology choices being made in new dwellings. The BESS data, which covers 57,278 dwellings (in 16,871 projects) constructed between mid-2016 and mid-2018, captures information on the type of heating system used in each dwelling. This data is shown in Figure 23. This figure shows the results for all dwelling types, but the data is available by dwelling type. The data indicates the primary space conditioning type and does not indicate whether secondary or tertiary types were also installed. It indicates that a large majority of new houses are choosing reverse cycle heat pumps for space heating – and this result was true for all dwelling types, but most pronounced in townhouses and least in detached dwellings.[53] Setting aside wood (which is generally used as a primary space heating source only in non-urban areas), Table 15 indicates that 93% of apartments in this data set, 80% of townhouses, and some 57% of houses, selected electrical technologies, with the balance gas, as their primary space heating appliance. It is likely that these trends reflect growing demand for space cooling, the declining costs and increasing energy efficiency of heat pumps over time, and the opportunity to avoid investing in multiple space conditioning devices and (potentially) connection costs. For the detached dwellings, 36% chose ducted central gas heating systems.

[53] As noted, however, detached dwellings represent a small share of the total data sample – only 999 out of 57,278 records.

Feedback on the draft report noted that these BESS outcomes may not be perfectly representative of outcomes over the whole study period, particularly since detached dwellings are poorly represented in the data set (less than 2% of the total). At the same time, it was noted that the only other data source was a single snapshot for 2011 (from BIS Shrapnel), and this data covers detached houses only for Victoria, so it does not help to illuminate relevant trends. Generally, the feedback suggests that there has indeed been a transition away from gas ducted central heating in detached houses, and towards reverse cycle air conditioning, consistent with the BESS data. However, there is insufficient data to have confidence about how this mix might in fact be changing over time across the whole state and for all dwelling types.

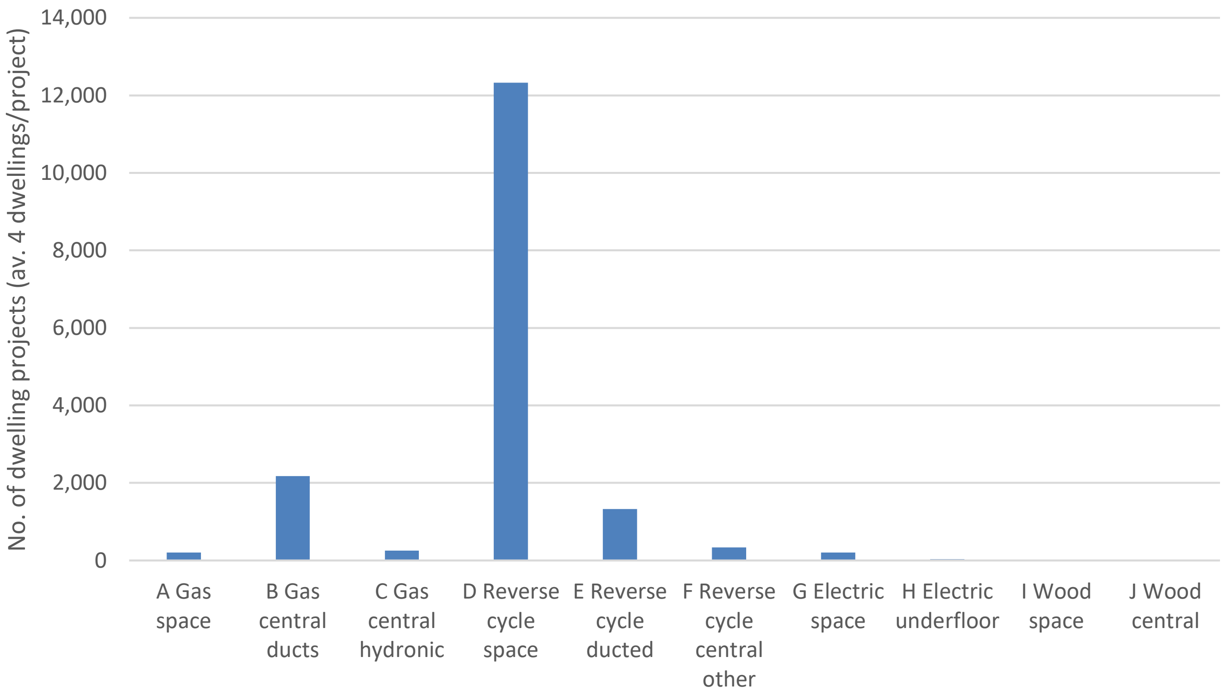


Figure 23: Space Heating Choices, New Dwellings – All Dwelling Types

Dwelling Type	Gas	Electric
Class 2 (Apartments)	7.0%	93.0%
Class 1aii (Townhouses)	19.6%	80.4%
Class 1ai (Houses)	43.5%	56.5%

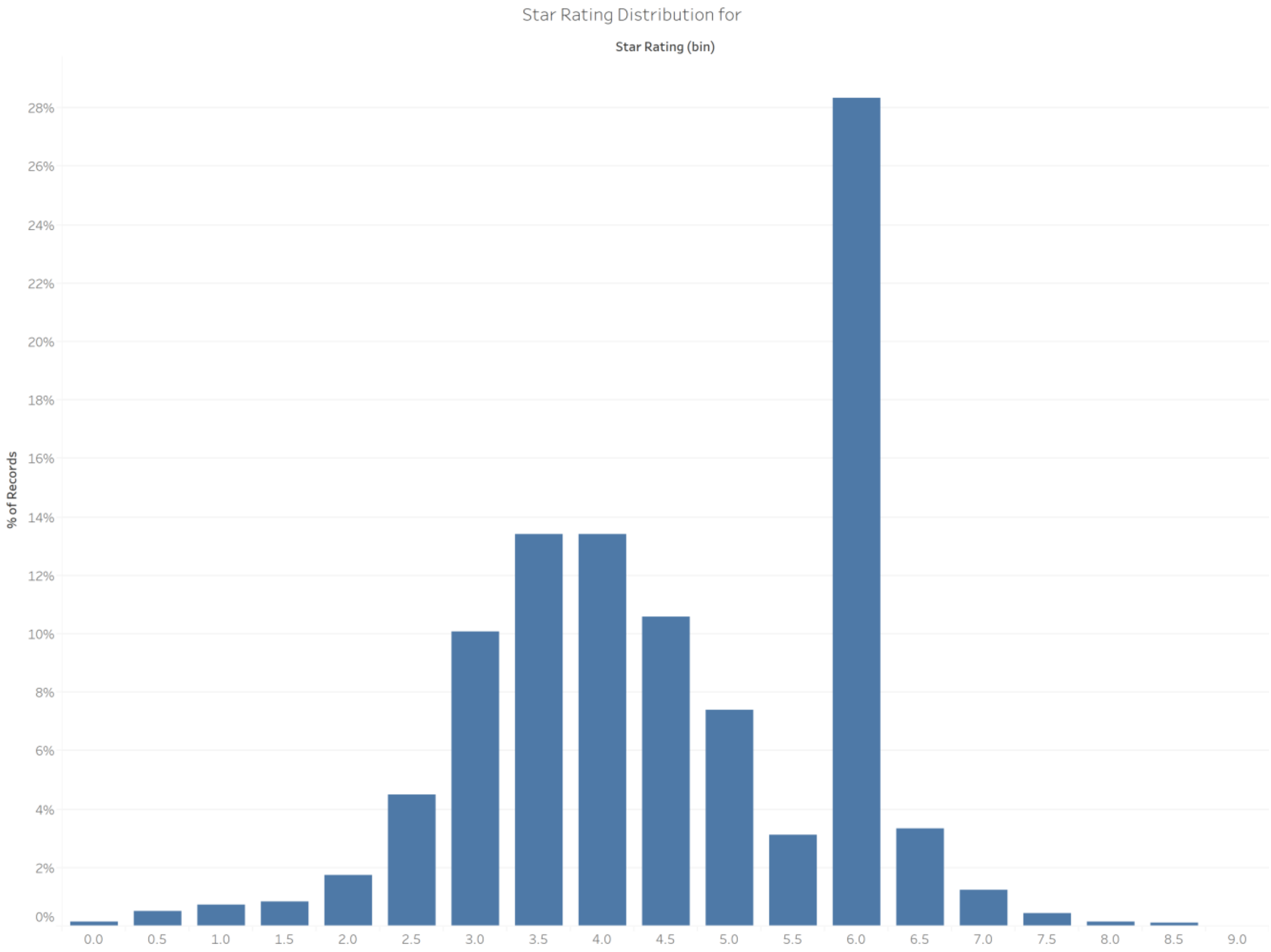
Table 15: New Dwelling Space Heating Choices, Victoria (2016 – 2018)

Given the dominance of gas space heating in the past, and noting that this BESS data only covers a recent 2-year period, we *assume* that the share of gas space heating was higher in earlier years (consistent with feedback on the draft report), with the switch from gas to electricity assumed to be 0.5% per year, including for the projection period (to FY2019). This appears consistent with data from BIS Shrapnel relating to 2011 only, supplied by DELWP, that indicates that in that year, 62% of new dwellings in Victoria featured ducted gas heating, while 40% featured ducted or split system air-conditioning (implying some contained both systems). This data is not broken down by dwelling type and only available for that one year.

6.1.3 Energy Savings

The energy savings attributable to 6-star are calculated in two steps: first, examining the NatHERs portal data for the actual distribution of ratings over time; and second, adjusting these to allow for the impact of other policies such as SDAPP, which incentivises 6.5-star rather than 6-star housing. We take into account both apparent under-compliance (eg, Class 1 dwellings at less than 6-star) and apparent over-compliance (those above 6-star). As noted, for Class 2s in particular, the 6-star average requirement means that, on average, 50% of ratings need to be above 6 in order for an overall building to be compliant. For Class 1s, higher than 6-star ratings (setting aside BESS for the moment) are interpreted as voluntary choices made by consumers. It is important to capture this as an element of 'what actually happened', but associated incremental costs cannot be attributed to 6-star, as the standard does not require these outcomes.

For the savings analysis, we assume that 50% of renovations, alterations and additions achieve compliance via the NatHERS pathway. However, there is no firm data to evidence this. Our understanding from stakeholders is that at least half of alterations and additions, and the majority of smaller ones, use elemental deemed-to-satisfy or DTS provisions, for simplicity. The judgement appears to be made that the costs of a NatHERS rating may exceed any benefit for smaller alterations and additions. NatHERS ratings for alterations and additions are complex and often require the existing house to be rated as well. An analysis of CSIRO's data for alterations and additions (the NatHERS rated share) – see Figure 24 – shows a marked skew towards much lower ratings than 6-star, even if 6-star is the most frequent rating recorded. For this report, we do not attempt to analyse this data or determine why less-than-6-star ratings are common, even if a small percentage achieve more than 6-stars. The analysis assumes that the 50% NatHERS share achieves 6-star on average.



% of Total Number of Records for each Star Rating (bin). The data is filtered on NCC class (group), Type (group), Certificate Date Year and Nat HERS Climate Zone. The NCC class (group) filter keeps Class 1. The Type (group) filter keeps Alteration & Alterations and Additions. The Certificate Date Year filter keeps 2016, 2017 and 2018. The Nat HERS Climate Zone filter keeps 75 of 75 members. The view is filtered on % of Total Number of Records, which ranges from 0.00% to 91.26%.

Figure 24: NatHERS Star Ratings, Alterations and Additions, All Dwelling Types, All Climate Zones (source: CSIRO)

Methodological Note

Our methodology examines the degree of change in annual average thermal load for each climate zone associated with moving from 5-star to 6-star. This value, in MJ/m2.a, is converted into an energy-equivalent by dividing them by relevant co-efficients of performance (COPs) of gas and electrical space heating equipment.[54] We do not apply any additional 'constraint factors', as sometimes occurs in NatHERS simulation work for factors such as thermostat settings, dwelling occupancy patterns or zoning behaviours (eg, preferences for heating/cooling whole houses or only some rooms), for example in an attempt to apply settings that may be considered more realistic. The primary reason for this is that we are examining the outcomes associated with the whole cohort of dwellings built to 6-star over time, as compared to the outcomes that would have occurred if that entire cohort had instead been built to 5-star, the previous standard. The cohort includes more

[54] Assumed to be 0.8 for ducted gas and 2.75 (in 2009) for reverse cycle air conditioners, rising to 4.4 by 2019 (from http://www.energyrating.gov.au/sites/new.energyrating/files/documents/201004-consult-ris-ac-2011_0.pdf)

than 560,000 dwellings. We have no statistical information about the thermostat settings, dwelling occupancy patterns or zoning behaviours in any of these dwellings, and therefore what may or may not be considered realistic. While non-default assumptions *could* be made about these factors, doing so in the absence of evidence would bring no new information into the study. Generally, for a policy evaluation, evidence should be preferred to assumptions wherever possible.

Second, we have no reason to expect that the thermostat settings, occupancy patterns and zoning behaviours in the 6-star dwelling cohort would be any different to those in the 5-star cohort. These factors represent personal preferences and behaviours, and we have no information to suggest that these differ between the two dwelling cohorts. Even if it could be shown that these factors were not identical, this would still not be relevant to this study unless it could also be shown than these differences were *caused* by the 6-star standard, and we have no reason to suspect this. For example, changes in occupancy patterns could occur due to changes in workforce participation, or trends towards working for home, for example. Given that the focus of this study is on the impact of the change in the star rating (from 5-star to 6-star) on expected energy consumption, and not on these other factors, we exclude these other factors from the study.

At the same time, we recognise there are important research questions surrounding the extent to which NatHERS ratings protocols are representative of actual household occupancy patterns and behaviours. Several stakeholders that we consulted, for example, suggested that the default thermostat settings (ratings mode) are up to 2 degrees too high in summer. This may have the effect of under-estimating summer cooling energy consumption in Victoria. It may also encourage designs that perform better in winter than in summer. We stress, however, that any such effects cannot be attributed to 6 star – the same assumptions applied for 5-star dwellings (noting that the NatHERS software protocol is adjusted from time to time, and therefore may not have been identical for all 5- and 6-star dwellings).

In this context, we note the Australian Building Codes Board commissioned SPR to prepare a Regulation Impact Statement on a regulatory proposal to apply separate heating and cooling load caps, or limits, for new residential buildings in much of Australia.[55] This proposal is expected to take effect in 2019 and is should help to ensure that new dwellings (that choose the NatHERS compliance pathway) offer well-balanced summer and winter performance characteristics. Arguably, and with the benefit of hind-sight, the absence of separate heating and cooling load limits was a limitation in the design of the 6-star measure. However, if this is so, it was also a limitation in the design of 5-star, and a limitation in the design of standards in all states and territories except NSW.

A final consideration is that the NatHERS ratings data, supplied for this study by CSIRO, represents ratings undertaking in 'compliance' mode. This means that factors such as thermostat settings, occupancy patterns and zoning were (deliberately) locked down to ensure that the results of all ratings for Code compliance purposes are comparable with each other. If this were not the case,

[55] These have applied in NSW for many years, and are not intended to be applied in climate zones that generate no or minimal heating loads (eg, Darwin) or cooling loads (eg, Hobart). The underlying technical analysis was undertaken by Tony Isaacs Consulting and Energy Efficient Strategies.

there would be the opportunity for these factors to be manipulated to make non-compliant designs appear compliant. Applying constraint factors post-hoc would introduce uncertainty as to what the ratings would have been had these, rather than the default, factors applied. For these reasons, our analysis assumes the default assumptions in ratings/compliance mode.

Results

Applying the actual, historical NatHERS ratings to the stock model described in Section 2, we estimate that total energy savings induced by the 6-star thermal standard will reach just under 2.3 PJ by FY2019 and persist for the economic lives of the 6-star building cohort (assumed to be 40 years)[56] – see Figure 25. Gas represents 71% of the savings, which reflects that fact that there are more houses than other dwelling types in the new building mix – even if the other classes are growing more rapidly – and new houses, as noted above, are using more gas for space heating than the other dwelling types. Therefore, the 6-star standard conserves more gas than electricity in Victoria.

Examining the BESS data, we find that 4% of Class 1 ratings in FY 2017 and 6.4% of Class 2 ratings were at 6.5-star. The unusual distribution of star ratings for Class 1s in particular was noted in Figure 21, and we attribute this effect to BESS and SDAPP. These schemes have been introduced progressively since 2005. While we do not have complete data on earlier (pre-2016 period), the NatHERS data for 2014 and 2015 (which, as noted, is largely unseparated by Class) shows around 5% of all ratings in those years were at 6.5-star. These values appear to be around twice as high as would have been expected in the absence of BESS. We therefore attribute of these ratings, and related energy savings, to BESS rather than 6-star. This reduces the peak energy savings shown in Figure 25 to just over 2 PJ from FY2019.

[56] A 40 year economic life for housing may understate the average life of housing in Victoria. An internal paper by DELWP (*Housing longevity in Victoria*, unpublished), suggests an average life of 57 years. Apartments are not considered, and townhouses and detached houses are treated as a single group. However, the effect of discounting is such that impacts that occur more than 40 years into the future would have only a small impact on the benefit cost analysis results. Nevertheless, the 40 year economic life assumption may slightly underestimate the benefits associated with energy performance regulation. It was also noted that the appliance mix and fuel mix of a house may change over its economic life. While this is true, it is not an effect that is attributable to the 6-star standard.

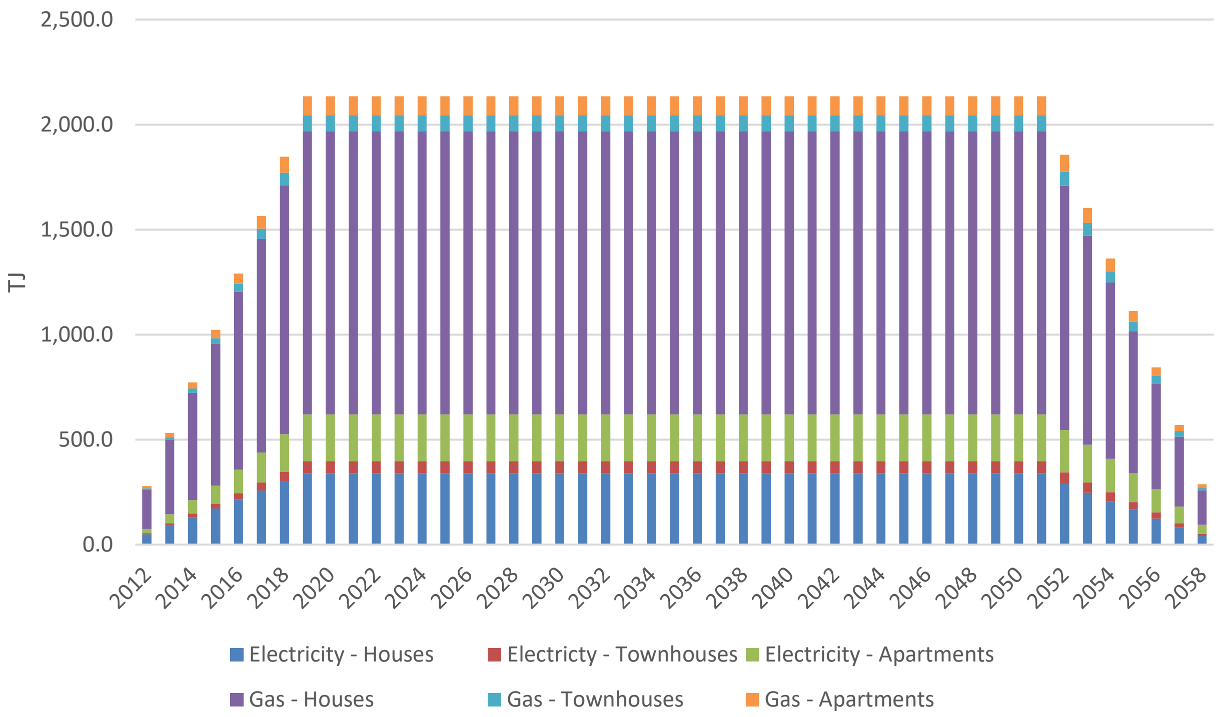


Figure 25: (Space Conditioning) Energy Savings by Fuel and Dwelling Type, 6-star (including BESS)

Applying the energy and carbon price data and real discount rate assumptions noted in Chapter 2, these energy savings have a present value (in FY2019 real dollars) of \$1.8 billion. Using the central shadow carbon price series, the present value of avoided carbon costs is \$277 million. This is based on the measure avoiding 219 kt CO2-e in F2019 – before falling over time due to the assumption of falling greenhouse gas intensity of electricity consumption in Victoria.

Using the CLF values noted in Chapter 2, these savings avoid just over 40 MW of peak demand in winter (and around 38 MW in summer), with a present value of \$483 million. Summing these individual benefit classes, the present value of the (quantifiable) total public benefit is just under \$2.6 billion in present value terms. Total private benefits, the value of energy savings only, have a present value of \$1.8 billion.

Applying the cost data from Section 2.5.6, the total value of incremental costs (in \$FY2019 real) rising from around \$183 million in FY2012 to \$218 million in FY2019, reflecting the growing volume of construction activity over this period. In present value terms, these costs are valued at \$1.2 billion. This indicates that the 6-star standard (without lighting, which is considered below) has realised a net gain in economic welfare of over \$1.3 billion (net present value in FY2019), with a benefit cost ratio of 2.1. That is, the value of benefits is more than double the value of costs. In private terms, the net benefit has a present value of \$576 million and a benefit cost ratio of 1.5, representing a private internal rate of return on investment of 7% per annum. On either basis, the measure is highly cost-effective.

6.1.4 Distribution of Savings

The *annual* social benefits and costs, in FY2019 real dollars, can be seen in Figure 26. The annual net benefit (or benefit minus cost), shown in the heavy black line, indicates that in the early years, the investment in higher energy performance outweighs the annual value of energy savings and other benefits. However, because these savings persist over the economic lives of the 6-star housing cohort, in total the benefits exceed the costs by around $150 million in most years shown. This explains why the present value of benefits is almost double that of costs. The internal rate of return on investment, including social benefits, is 11% per annum.

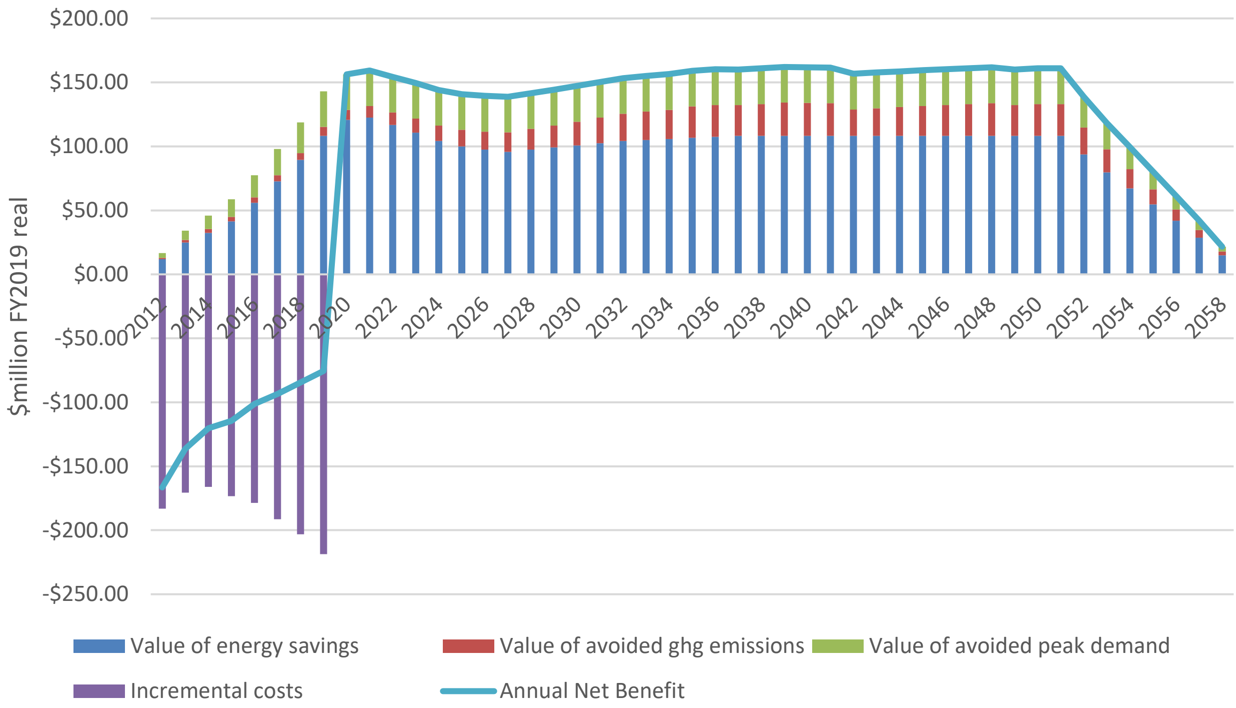


Figure 26: Annual Value of Social Benefits and Costs by Type, 6-star Energy Requirement, Victoria

6.2 Lighting

As noted in Chapter 2, the lighting provisions – essentially, the introduction of a 5W/sqm limit on wired-in lighting systems (from 2012) – is modelled separately from the space conditioning savings, drawing on detailed analysis for Victoria by GWA in 2007 as a starting point.[57] In the BAU scenario, we assume that:

- incandescent (non-halogen) lighting is fully phased out by 2012
- 'premium' (halogen) systems continue to dominate, due to their consumer appeal and relatively low lamp cost (although, as noted below, not installed or operating cost)

[57] George Wilkenfeld & Associates/Energy Efficient Strategies, *Options to reduce emissions from new homes in Victoria through the building approval process*, April 2007.

- CFLs are assumed essentially to 'compete' with LEDs, and LEDs slowly increase their (new housing) market share from around 2012 onwards – due to market trends such as reducing lamp cost and growing awareness of their efficiency benefits, rather than any policy driver.

This is depicted for Class 1 dwellings in Figure 27 below. Note that this is a counter-factual scenario (that is, what might have happened in the absence of the 6-star standard) and therefore must be estimated.

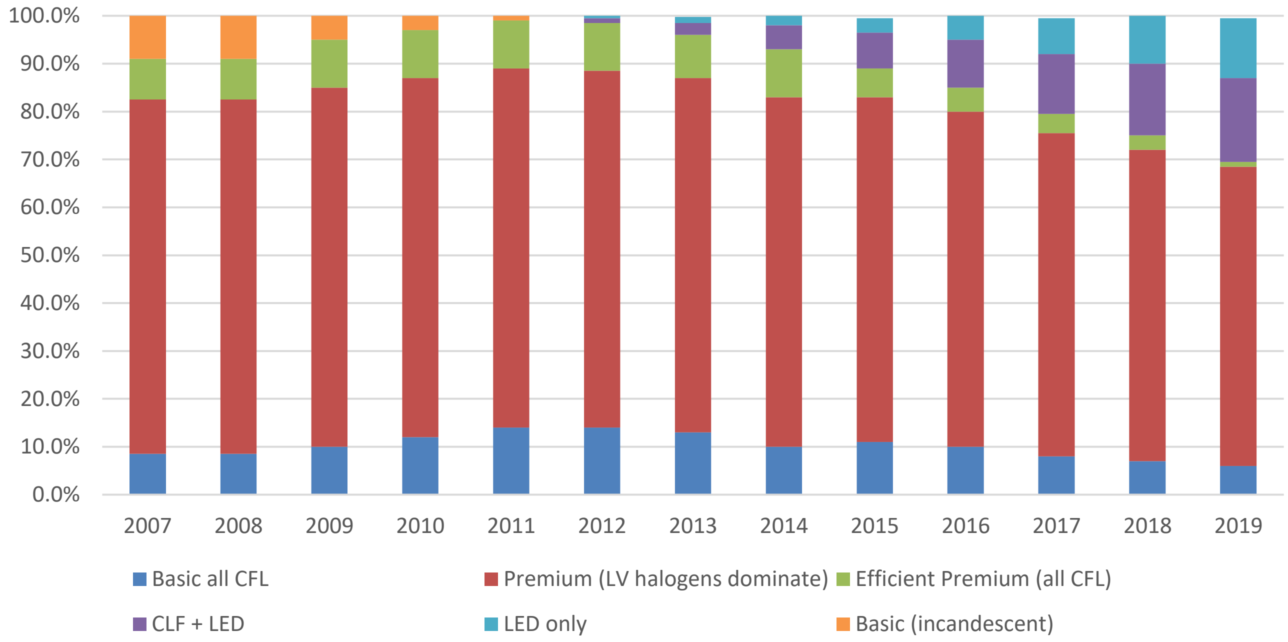


Figure 27: Class 1 New Dwelling Lighting Mix Assumptions – BAU

The lighting solution mix described by GWA for Class 2 dwellings shows a higher share of incandescent lamps, and a lower share of halogens, in 2007, but the two classes are assumed to adopt a similar lighting mix following the phase-out of incandescent lamps from 2009.

In terms of analysing the impact of the 6-star standard on new dwelling lighting, we note that the lamp power density of the different light solutions varies widely, as shown in Table 16. This table also notes the different number of lamps assumed to be installed per dwelling in the differing lighting solutions, and for Class 1 and Class 2 dwellings. It can be noted that the premium/halogen solution significantly exceeds the 5W/sqm limit, as does the basic/incandescent solution. Based on the BAU lighting mix, the weighted average lamp power density varies over time between 10.5 W/sqm (in 2007) to 13.2 (in 2011, when halogens are assumed to peak), and fall to 11.3 by 2019 (with a rising share of LEDs in the mix).

Class 1	kWh/year	W/m2	No. of Lamps
Basic (incandescent)	7.4	11.9	46
Basic all CFL	1.6	2.8	46
Premium (LV halogens dominate)	11.6	19.6	96
Efficient Premium (all CFL)	3.3	5.5	103
CLF + LED	2.3	3.9	103
LED only	1.3	2.2	103
Class 2	**kWh/year**	**W/m2**	**Lamps**
Basic	5.0	8.8	14
Basic CFL	1.1	1.9	14
Premium	9.6	16.6	33
Efficient (all CFL)	2.6	4.4	35
CLF + LED	1.9	3.2	35
LED only	1.1	1.9	35

Table 16: GWA Lighting Scenarios – Key Indicators (LEDs added)

We then vary the shares of lighting solutions to determine the most likely mix, based on market trends, that is compliant with the 5W/sqm requirement. This is shown for Class 1 dwellings in Figure 28. The primary difference, relative to BAU, is that only a small share of the premium/halogen mix can be included while still meeting the overall limit. Note that we do not assume that halogens cease being used in new housing; however, 100% halogen solutions would not be Code-compliant. Again, we assume the Class 2 mix is similar to Class 1. As in the BAU scenario, we assume the 'efficient CFL' households, as described by GWA, make way for hybrid CFL/LED, and increasingly all-LED, solutions over time. The weighted average lamp power density implied in Figure 28 varies between 4.6 and 5.0 W/sqm; that is, it is Code-compliant in all years.

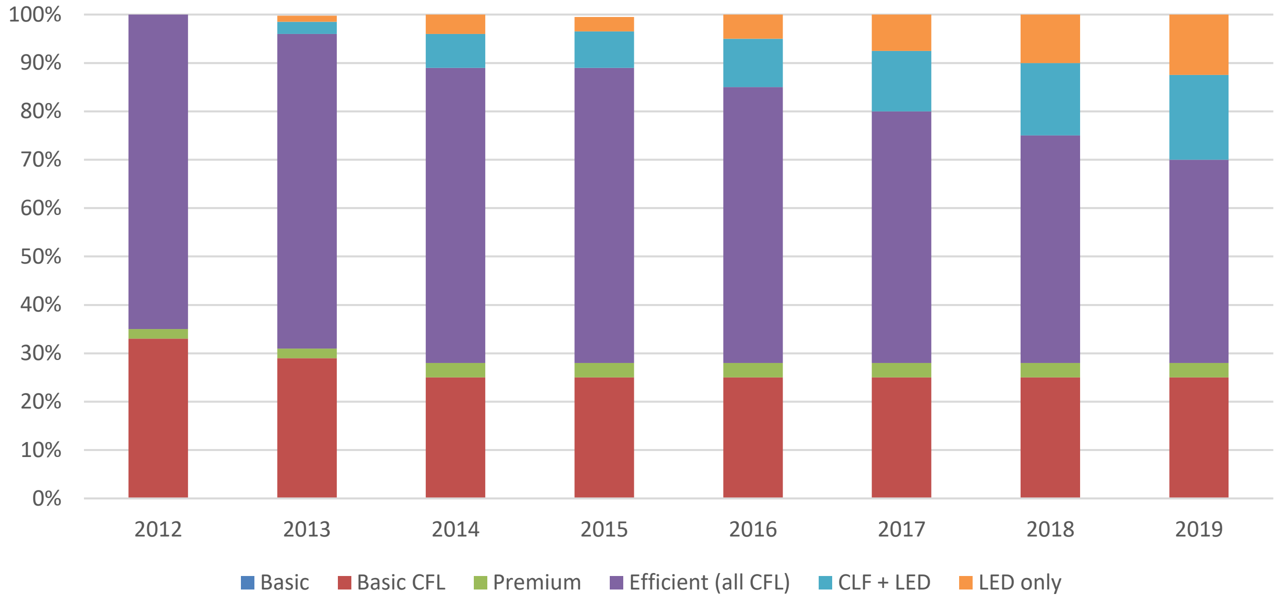


Figure 28: 6-star New Class 1 Dwelling Lighting Mix Assumptions

The resulting lighting energy savings by dwelling type are shown in Figure 29. Note that we assume that lighting systems (as distinct from individual lamps) have an average economic life of 15 years: lamp replacement is a minor expense relative to the much larger installed cost of lighting systems. This assumption is derived from the analysis in GWA (2007). Extending this assumption to 25 years, for example, would not change character or conclusions of the analysis – although it would imply even larger economic savings than those estimated here. Following the 15-year economic life assumption, the energy savings *attributable to 6-star* taper off from 2027 onwards. The analysis does not consider the nature of replacement lighting systems in future, as this will be affected by factors than are not attributable to the 6-star standard.

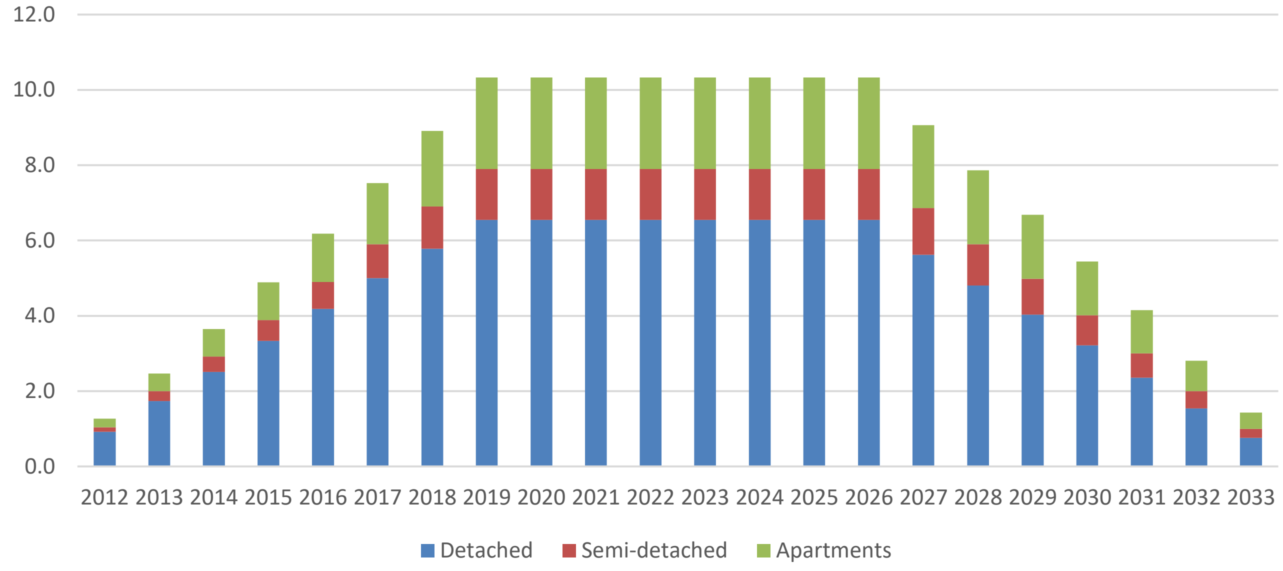


Figure 29: 6-star Lighting Energy Savings by Dwelling Type

The benefits associated with these savings are calculated using the same methodology and assumptions as noted previously – eg, electricity prices, shadow carbon prices and avoided network costs. For the latter, we use conservation load factors (CLF) developed for Victoria by Jacobs.[58] While the CLF value for summer is high at 2.68[59] – indicating that lighting demand savings have no material peak demand benefits in summer – the winter value of 0.34 is lower, indicating peak load reduction benefits will occur in winter. This pattern reflects the shorter daylight hours in winter, leading to lighting demand coinciding with system peak demand, while this is much less likely to occur in summer.

The energy savings shown have an annual value that peaks at just over $1 million, while avoided carbon costs add modestly to these total (peaking at $0.1 million). The maximum avoided peak demand is 0.8 MW, with an annual value of $1.3 million. That is, the total benefits peak at $2.5 million per year by 2021, and have a present value in FY2019 of $30.6 million.

In terms of the cost side of the analysis, GWA calculates 2007 costs associated with each lighting solution. Recall, as above, that the number of lamps installed varies for the different solutions, and this helps to explain the differing costs. Also, noting that installation (rather than lamp) costs dominate the total capital costs, we separate the total cost into lamp and installation costs, with the latter assumed to remain constant in real terms (reflective of real wage trends), while we apply different 'learning rates' or cost reductions over time to lamps. LEDs are estimated to have

[58] Jacobs, *Energy Market Impact of the VEET Scheme*, Draft Report, April 2015, Appendix C.
[59] A value of 1 (sometimes expressed as 100%) means a perfectly flat load, while values greater than 1 indicate that loads are shifted towards off-peak periods, and values less than 1 indicate loads shifted towards peak periods

experienced a learning rate of 28% per year around the middle part of this decade.[60] Compact fluorescent lamps are noted by the International Energy Agency as having experienced a 10% learning rate earlier this decade (other sources note higher values in earlier time periods – noting that this technology first emerged in the 1970s).[61] No learning rate data was able to be sourced for low-voltage halogen lamps, but we assume a 3% per annum rate over the study period; while we assume no learning rate for the (mature) incandescent lamp technology – see Table 17.

Lighting Solutions	Class 1 installed capital cost (2018)	Class 2 Installed capital cost (2018)
Basic (incandescent)	$3,560.00	$1,098.00
Basic all CFL	$3,280.71	$1,017.87
Premium (LV halogens dominate)	$6,439.34	$1,962.02
Efficient Premium (all CFL)	$5,714.45	$1,806.67

Table 17: Lighting Solution Total Costs by Dwelling Type (derived from GWA 2007)

For LEDs, we are constrained to work backwards from current pricing, applying the 28% annual learning rate above, as we could not source reliable past price estimates going back to 2012. For current costs we assume a lamp cost of $20.00 (based on a commercial quote for 8W, dimmable and enclosed lamp units – noting that cheaper designs are available) and an installation cost of just under $52/lamp. For comparison with the GWA values, the 100% LED solution has an estimated capital cost of $7,382 for Class 1s, on the same lamp numbers as assumed by GWA, and $2,508 for Class 2s (reflecting the smaller number of lamps).

The significant result of the cost analysis is that the shift in lighting system mix, as described above, is modelled to *reduce* the overall installed capital cost of lighting systems in new dwellings, as compared to the BAU lighting solutions. This occurs because, as noted, the all-halogen 'premium' solution is not Code-compliant and must be constrained, while CFL-based systems (particularly at the basic, rather than premium, end of the spectrum) have a *lower* installed cost than halogens. At the same time, while LED solutions are more expensive (per installed lamp) than other solutions until around 2016, their faster learning rate (and also modest take-up in the earlier part of the analysis period) does not contribute excessive cost.

Overall, we model a capital cost *saving* of between $16 million and $44 million per year, valued at $265 million in present value terms in FY2019. This result dominates the operational energy cost saving associated with the 5W/sqm lamp power density limit, which has a present value of just under $22 million (public basis, including the value of avoided shadow carbon costs). These results mean that this aspect of the 6-star program would remain cost-effective even if different possible

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[60] Lawrence Berkerley National Laboratory, *Recent price trends and learning curves for household LED lamps*, 2015, p. 12.
[61] International Energy Agency, *Energy Technology Perspectives*, 2010, cited in http://www.climatetechwiki.org/technology/cfl#References

combinations of lighting solutions than modelled above were assumed, with potentially higher capital costs. Summary benefit cost analysis results are shown in Table 18. Note that a negative benefit cost ratio occurs when capital costs fall and that this is a good, rather than poor, result. The private BCA results are very similar to the public results, with the sole difference being that the private results exclude the benefit associated with avoided shadow carbon costs, meaning that the observed net benefit is slightly lower.

Indicator	Value ($ million FY2019)
Present value of benefits	$21.71
Present value of costs	-$265.11
Net present value	$286.81
Benefit cost ratio	*negative*

Table 18: Lighting Public Benefit Cost Analysis – Summary Indicators

Indicator	Value ($ million FY2019)
Present value of benefits	$14.28
Present value of costs	-$265.11
Net present value	$279.39
Benefit cost ratio	*negative*

Table 19: Lighting Private Benefit Cost Analysis – Summary Indicators

6.3 Solar Hot Water Option

6.3.1 Solar Hot Water Uptake

Th primary data available from the VBA (which commences in 2008) suggests that some 52% of new Class 1 dwellings have selected a solar hot water heater, 23% a rainwater tank, and 25% not stated – see Table 20. It is believed that the 'unstated' choices reflect a lack of reporting rather than a lack of compliance. As a result, we have 'grossed up' the percentages of new Class 1 dwellings selecting solar hot water and rainwater tanks and applied them to the whole sample – as shown in Table 21.

Year	New Dwelling (Class 1)	Solar Water Heater	Rain Water Tank	Solar % of Total	Tank % of Total	Not Stated
2008	30,645	12,045	10,192	39%	33%	27%
2009	33,302	17,168	8,740	52%	26%	22%
2010	38,613	20,518	9,284	53%	24%	23%
2011	32,348	18,243	7,903	56%	24%	19%
2012	28,503	16,685	6,888	59%	24%	17%
2013	27,916	14,933	6,688	53%	24%	23%
2014	32,244	18,066	6,765	56%	21%	23%
2015	34,675	19,831	7,314	57%	21%	22%
2016	36,935	18,246	6,665	49%	18%	33%
2017	39,345	17,871	6,914	45%	18%	37%

Table 20: VBA Permit Data on Uptake of Solar Hot Water and Rainwater Tanks - Summary

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Solar Water Heater	16,599	22,068	26,584	22,570	20,174	19,281	23,459	25,332	27,053	28,369
% of New Class 1as	54%	66%	69%	70%	71%	69%	73%	73%	73%	72%
Rain Water Tank	14,046	11,234	12,029	9,778	8,329	8,635	8,785	9,343	9,882	10,976
% of New Class 1as	46%	34%	31%	30%	29%	31%	27%	27%	27%	28%
Total	30,645	33,302	38,613	32,348	28,503	27,916	32,244	34,675	36,935	39,345

Table 21: Grossed Up Shares of Solar Hot Water and Rainwater Tank Choices

6.3.2 Solar Hot Water Heaters

To calculate the energy savings attributable to the Code variation, we need to know, or at least estimate:

- Which hot water systems were displaced by the variation, year on year?
- How many solar hot water systems were gas- and electricity-boosted, year on year?
- What were the resulting energy savings?
- What were the incremental costs, relatively to the displaced systems?
- Does the value of savings outweigh the costs, or vice versa?

As discussed in Chapter 2, however, much of the data that would ideally have been used to undertake this analysis was simply unavailable. Following extensive discussions, the set of assumptions noted in Table 6 and Table 7 were agreed as reasonable, and the following results reflect those assumptions.

The Small-scale Technology Certificate (STC) scheme has applied since 2009, and it provides support in the form of a unique number of certificates for each hot water system. We examined a sample of gas- and electrically-boosted systems using Rheem's Smallscale Technology Certificates calculator,[62] and noted that typical electrically-boosted systems average 30.5 certificates, while typical gas boosted systems average 28.5 certificates – although precise values will vary by system size, number of collectors and other factors. With STC pricing varying between $30 and just over $50 in real, or inflation-adjusted, terms, this may have contributed up to $1500 for a solar hot water system (in 2007) but closer to $1,000 since around 2013. We note that our STC prices are sourced from a various of online sources for earlier years, and we assume 2017 average prices apply in 2018 and 2019.

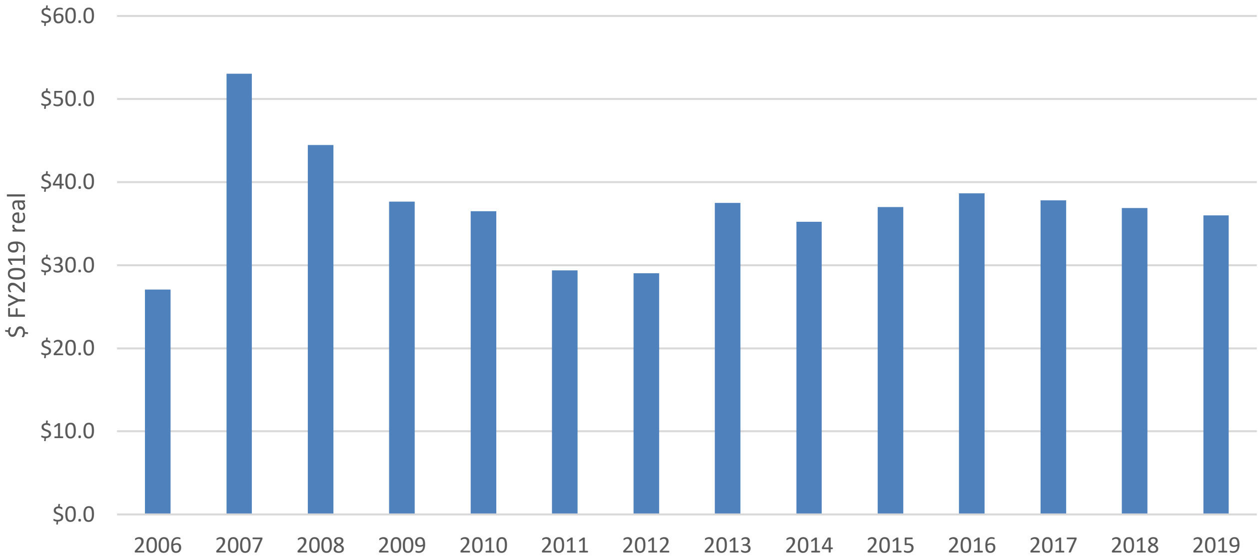

Figure 30: STC Average Prices, FY2019 real

We established the relative (installed) costs of hot water system choices primarily using Cordell's *Building Cost Guide for Victoria,*[63] but also checked values with other sources.[64] For costs in earlier time periods, we applied the Victorian Producer Price Index specifically for plumbing products (Melbourne).[65] The FY2019 prices are shown in Table 22. For the purposes of benefit cost analysis, and based on intelligence available to Ark Resources, the prices shown assume that bulk-purchase discounts of 20% apply relative to Cordells' pricing.

Hot Water System Type	Typical Installed Cost (incl. GST)
Electric Water - Med/Large	$1,119.07
Electric Water - Small	$807.90

[62] http://www.rheem.com.au/SmallscaleTechnologyCertificatesSTCs
[63] Cordell, *Housing: Building Cost Guide: Victoria*, October 2017.
[64] See, for example, https://australianhotwater.com.au/6-steps-calculating-price-hot-water-system/
[65] Australian Bureau of Statistics, *6427.0 Producer Price Indexes, Australia, Table 18. Input to the House construction industry, six state capital cities, weighted average and city, index numbers and percentage changes*.

Gas instant (LPG)	$1,198.26
Gas instant (mains)	$1,198.26
Gas storage (LPG)	$1,345.95
Gas storage (mains)	$1,345.95
Heat pump	$3,498.64
Solar electric	$3,904.64
Solar gas	$4,847.40

Table 22: Typical Hot Water System Prices, Victoria, installed incl. GST, FY2019

To establish the energy savings associated with the take-up assumptions in Table 6 and Table 7, we examined several sources for the average energy consumption of different hot water systems in Victoria, including the Baseline Study noted above, a Rheem running cost calculator,[66] and data from Energy Efficient Strategies produced for the VEET program and provided by the Department of the Environment, Land, Water and Planning. The latter was eventually preferred, as it includes lower estimates of hot water usage that were established based on EES's bottom-up research, rather than other estimation techniques. As a result, average annual energy consumption data assumed for the range of hot water technologies is lower than may be found elsewhere, but is arguably more realistic – see Table 23. Further, because the hot water consumption usage is reduced, regardless of hot water technology, the *difference* in annual energy consumption between technologies was not greatly different from that suggested by the Rheem calculator, for example.

	Small household (GJ/y)	Medium household (GJ/y)	Large household (GJ/y)
Electric storage	7	11.3	12
Gas storage 5-star	10.8	14.8	
Instant gas 5-star	6.1	10.2	14.2
Instant gas 6-star	5.3	8.9	12.4
Solar electric boost	1.1	1.4	1.7
Solar gas boost	2.2	2.7	3.2
Heat pump	2	2.5	3

Table 23: Estimated Average Annual Energy Consumption, Selected Hot Water Types, Victoria (based on EES data)

For modelling purposes, we apply the medium household values to represent the average. The savings for each system are assumed to persist for 20 years, noting that some references place the average economic life of a solar hot water system between 20 – 25 years.[67] We make no assumptions about end-of-life replacement, as these future choices are unlikely to be materially influenced by the 2005 Code variation.

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[66] http://www.rheem.com.au/RunningCostCalculator

[67] See http://large.stanford.edu/courses/2010/ph240/contryman2/ and http://anzasca.net/wp-content/uploads/2014/08/ANZAScA2006_Robert-H-Crawford_Graham-J-Treloar.pdf

The energy savings accumulate year on year to reach a peak of more than 1.6 PJ by 2019, with gas dominating the savings – see Figure 31. These savings are valued at over $86 million in that year (in FY2019 real dollars) and have a present value of $819 million.

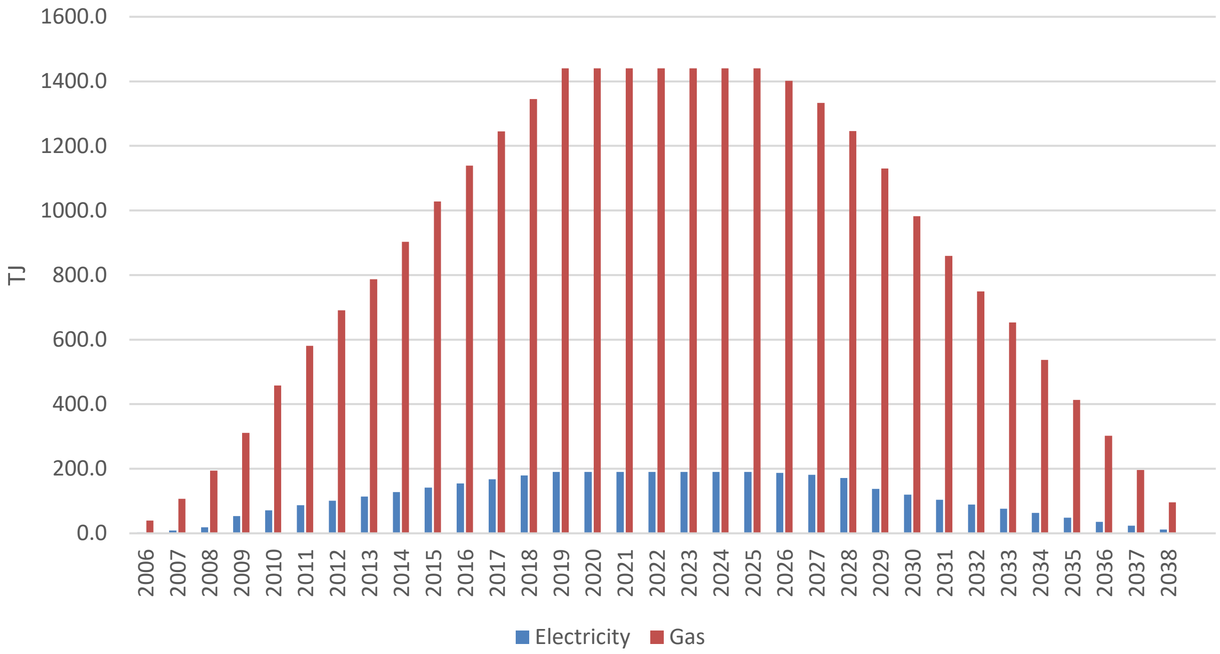


Figure 31: Solar Hot Water System Energy Savings by Fuel, Victoria

These energy savings lead to reduced greenhouse gas emissions that peak at over 122,000 t CO2-e in FY2019, before falling over time due to our (CSIRO/ENA) assumption of declining greenhouse gas intensity of electricity consumption in future (see Figure 4). Valued using the central shadow carbon price assumption, the avoided emissions have a present value of $63.6 million. With most hot water boosting being shifted to off-peak times, we assume no change in peak demand as a result of these hot water energy consumption savings, and therefore we do not assume any network benefits. In total, then, the solar hot water (public) benefits attributable to the Code variation have a present value of $883 million. Private benefits are valued at $819 million, netting off the avoided shadow carbon costs.

The total incremental costs – measured in public cost terms, before counting the effect of subsidies – are estimated to have reached a peak of $86.6 million in FY2015 (FY2019 real dollars), before falling to around $68 million in FY2019, due to the projection of a slight increase in the share of (less expensive) electric vs gas boosted solar systems. These costs have a present value of $634 million on a public basis. Combining the value of public benefits and costs, this element of Code variation has a net present value of $249 million, a benefit cost ratio of 1.4 and an internal rate of return of 9%. That is, the measure is comfortably cost-effective on reference assumptions. However, this

BCR is the lower than those offered by the other elements of the policy package. Annual (public) benefits and costs are shown in Figure 32.

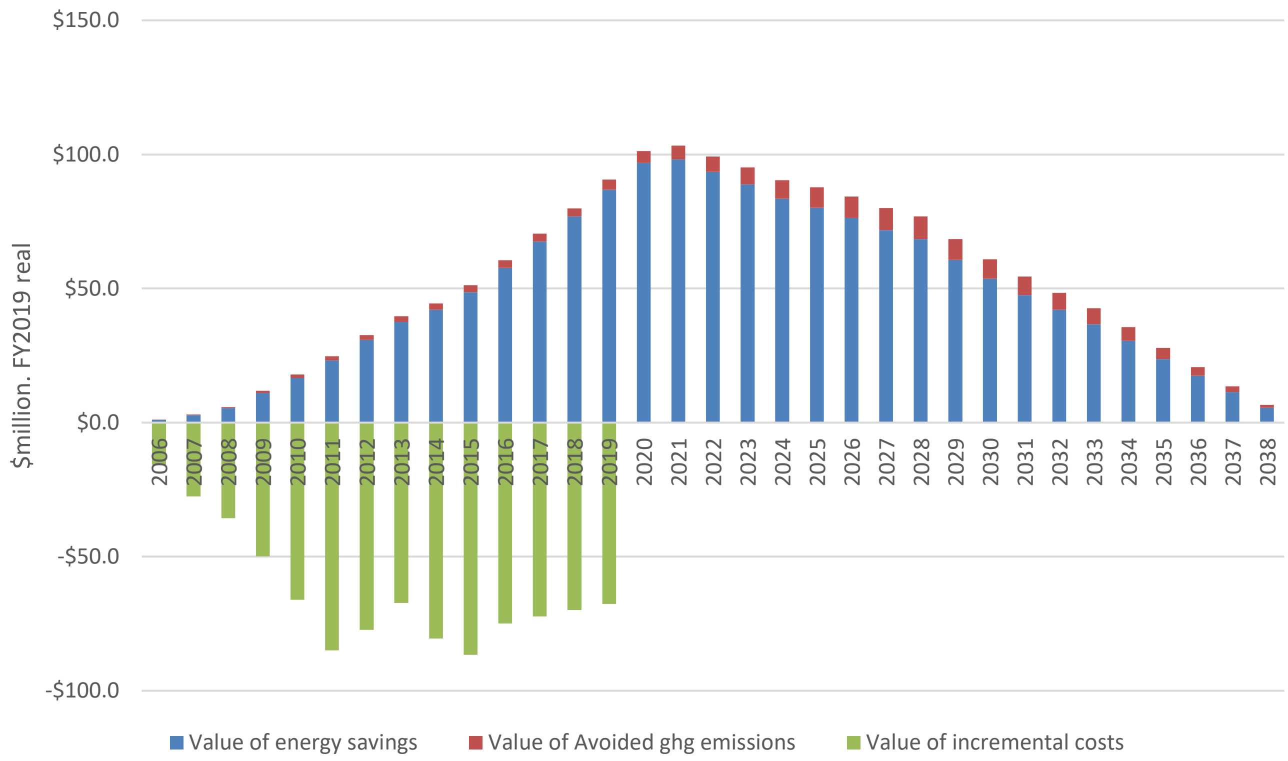


Figure 32: Annual Values of Public Benefits and Costs: Solar Hot Water

On a private benefit/cost basis – taking into account the availability of financial supports from STCs – the measure appears significantly more cost-effective. The present value of energy savings is $819 million (lower than public benefits, due to the absence of shadow carbon cost reductions), but the present value of costs to consumers is just under $420 million, leaving consumers better off by almost $400 million in present value terms. On this private benefit/cost basis, the benefit cost ratio is 2.0 and the internal rate of return 14% - see Figure 33. The difference between the public and private scenarios is accounted for by the value of consumer transfers associated with the Small Technology Certificate (STC) scheme, which is financed by loadings on energy bills and returned to those participating in and benefiting from these schemes.

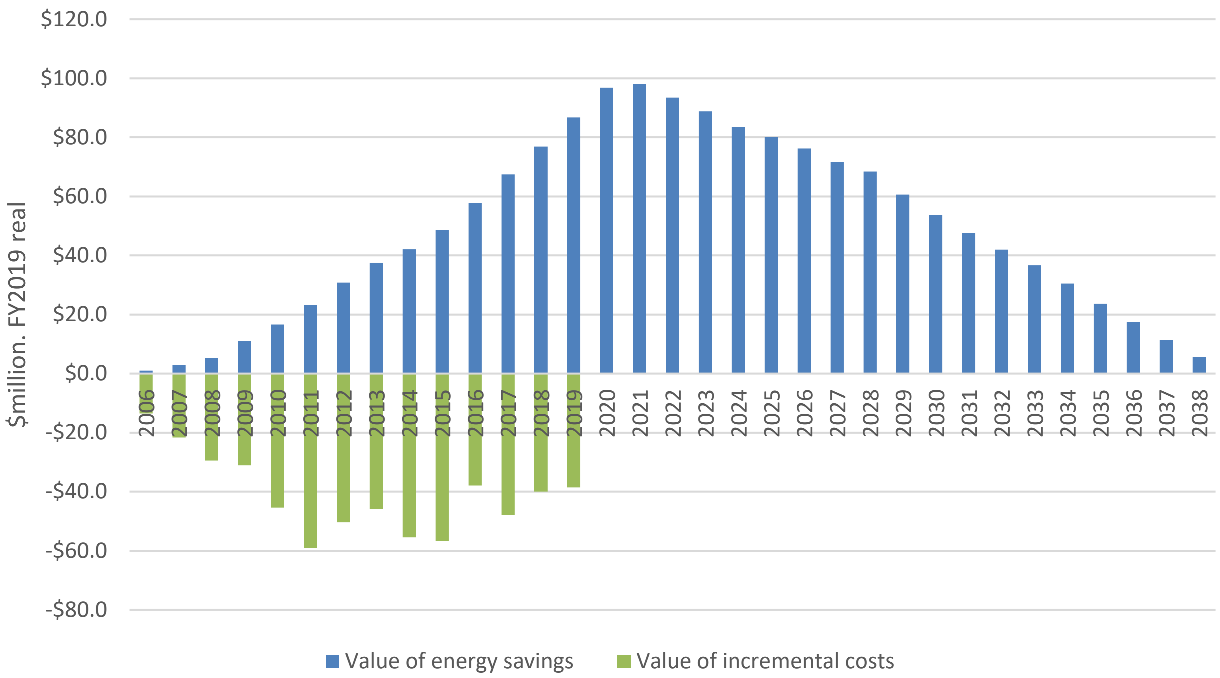


Figure 33: Annual Values of Private Benefits and Costs: Solar Hot Water

6.3.3 Sensitivity Analysis

The results as presented above are modestly sensitive to input assumptions, as discussed below.

Real Discount Rates

If we select a 7% real discount rate – as commonly used by the Australian Government – then the solar hot water heater provision appears only marginally cost-effective on a public benefit cost basis, with a BCR of 1.1 (Table 24).

Generally, it can be noted that the apparent cost effectiveness of all the measures falls with a 7% real discount rate. This is because the benefits of the package occur over longer periods of time (to at least 2058) than do the costs (to 2019), recalling that the effect of discounting is to progressively reduce the present value of future values (costs or benefits) over time. Therefore, increasing the discount rate disproportionately reduces benefits, but has relatively little impact on costs. Note that IRR values do not vary when discount rates are changed and therefore these are not shown.

FY2019$m real, 7% real discount rate	Energy (incl. lighting)	Solar Hot Water	Totals
Public Benefits	$1,566	$564	$2,131
Public Costs	$865	$507	$1,373
NPV	$701	$57	$758
BCR	1.8	1.1	1.6
Private Benefits	$1,120	$526	$1,646
Private Costs	$865	$420	$1,285
NPV	$255	$106	$361
BCR	1.3	1.3	1.3

Table 24: BCA Sensitivity Analysis – 7% Real Discount Rate

Conversely, selecting a discount rate of zero (which implies that values that occur in all time periods are weighted equally), dramatically increases the apparent cost-effectiveness of all measures (Table 25). Overall, the BCRs rise to 4.1 on a public basis and 3.4 on a private basis. As above, the reason is the time distribution of the benefits. It may be noted that the present values of costs are not greatly changed with a 0% discount rate, as compared to the reference 4% rate, while the present values of benefits are significantly increased. This is because future values, right out to 2058, are summed without any discounting.

FY2019$m real, 0% real discount rate	Energy (incl. lighting)	Solar Hot Water	Totals
Public Benefits	$6,131	$1,731	$7,863
Public Costs	$1,163	$876	$2,039
NPV	$4,968	$855	$5,824
BCR	5.3	2.0	3.9
Private Benefits	$4,261	$1,594	$5,855
Private Costs	$1,163	$420	$1,582
NPV	$3,098	$1,175	$4,273
BCR	3.7	3.8	3.7

Table 25: BCA Sensitivity Analysis – 0% Real Discount Rate

Strictly, the responsiveness of a benefit cost analysis to changing real discount rate assumptions is not a true sensitivity analysis. Sensitivity analysis is designed to test the robustness of analyses to changes in real values that could indeed occur – such as energy prices, or compliance costs. By contrast, the real discount rate is an assumption, and not discoverable even after the fact.

Mathematically, noting that the 6-star package remains cost effective (overall) at a 7% real discount rate is the same as saying that the average internal rate of return for the package of measures exceeds 7%.

Shadow Carbon Prices

Selecting the high shadow carbon price series lifts the overall NPV of the set of measures by around $200 million to just under $2.1 billion, with a BCR of 2.3 (cf, 2.2 reference) on a public basis. Private benefits and costs are not changed. Selecting the low shadow carbon price series reduces the public NPV by a similar amount, of around $200 million, to just under $1.7 billion, and the BCR to 1.9. The relative insensitivity of the results to the level of shadow carbon pricing reflects the fact that the shadow prices themselves are quite small relative to the market price of electricity or gas. Overall, the cost effectiveness of the measure is not dependent upon or markedly affected by shadow carbon price assumptions.

FY2019$million real, 4% real discount rate	Energy	SHW	Totals
Public Benefits	$2,761	$950	$3,710
Public Costs	$977	$634	$1,611
NPV	$1,784	$316	$2,099
BCR	2.8	1.5	2.3
IRR	14%	10%	12%

Table 26: Sensitivity Analysis – High Shadow Carbon Prices

FY2019$million real, 4% real discount rate	Energy	SHW	Totals
Public Benefits	$2,433	$849	$3,281
Public Costs	$977	$634	$1,611
NPV	$1,456	$215	$1,671
BCR	2.5	1.3	2.0
IRR	12%	8%	11%

Table 27: Sensitivity Analysis – Low Shadow Carbon Prices

Incremental Construction Costs

We noted that there is uncertainty about the extent of incremental construction costs required to comply with the 6-star standard rather than the preceding 5-star standard. Increasing the reference incremental construction cost values by 25% in all time periods has the effect of reducing the public NPV (of the 6-star measure only) to $1.03 billion and BCR to 1.7, and the private NPV to $265 million and BCR to 1.2. If incremental construction costs were 25% lower than assumed in all periods, this would increase the public NPV to $1.65 billion and BCR to 2.8, while the private BCR would increase to $886 million and BCR to 2.

Overall, we see a modest sensitivity to incremental cost assumptions, with +/- 25% changes failing to change the sign of NPV. That is, the cost-effectiveness of the 6-star element is highly robust in the face of significant changes in construction cost assumptions.

Lighting

The lighting element is extremely cost effective, with this result driven by the finding that incremental capital costs associated with the 6-star lighting mix are actually lower than the business as usual lighting mix, even after allowing for technological change. In such a case, the scale of benefits delivered is not material. Even if LED lighting costs are increased by 50% in all time periods, the NPV of the measure falls only marginally to $284 million on a public basis and $277 million on a private basis, while BCRs remain negative (due to the capital cost saving).

Solar Hot Water

The solar hot water element generates the lowest public BCR of the policy, albeit that the central case benefit cost ratio of 1.4 is comfortably cost-effective, and the internal rate of return of 9% is more than twice the reference discount rate of 4%. However, these values are lower than other elements primarily because gas-boosted solar hot water systems are amongst the highest cost of hot water systems. Also, they are not the most energy efficient option available – at least on the basis of final energy consumption. Electrically-boosted solar and heat-pump technologies consume less energy on average. However, gas boosted solar is a low greenhouse gas emissions option, due to the high emissions intensity of grid-sourced electricity in Victoria.[68]

The key uncertainty, that we test with sensitivity analysis, is the extent of annual energy savings realised when gas-boosted solar hot water is chosen. This is in turn dependent upon the technology or basket of technologies assumed to be *replaced* by the gas-boosted solar, and secondly on hot water consumption patterns by households.

It was noted above that we examined two main data sources that offer observations about the annual energy consumption of different hot water technologies, including as a function of assumptions about average annual or daily hot water consumption: a Rheem online calculator and Energy Efficient Strategies data previously commissioned by the Department. The Rheem calculator indicates higher values for annual energy consumption for all hot water technologies than EES. This is most likely the calculator draws on Australian Standard methodologies and assumptions, including about daily average hot water consumption. The EES data, on the other hand, is based on Victorian studies that indicate lower levels of daily average hot water consumption than those assumed in the Australian Standard. As a result, employing the Rheem calculator assumptions generated a lower net present value of public benefits of $104 million, which is less than half of estimate

[68] Provided they are functioning as intended, and not consuming more gas than expected. Some stakeholders expressed concerns regarding the quality and reliability of systems installed and regarding the quality of the installation work.

generated from EES data ($249 million). However, the measure remains cost effective even if the Rheem data is used.

We note that hot water usage and energy consumption is a complex field, where actual energy consumption will vary significantly from household to household due to many factors. A full investigation would require a much more detailed study, drawing on more extensive data. Also, it has not been within the scope of this study to investigate the more critical stakeholder feedback noted in Chapter 4 and Appendix D.

7. Analysis and Conclusions

7.1 Summary of Key Findings

7.1.1 Resource and Emissions Savings

Table 29 overleaf summarises the energy, water and emissions savings generated by the 6-star energy performance standard, including lighting provisions, and Code variation/plumbing regulations for solar hot water (or rainwater tanks). In cumulative terms, over the period to 2058 (depending upon the economic lives of the assets in question), the measures save over 114 PJ of energy and 8.7 million tonnes CO_2-e of greenhouse gas emissions.

7.1.2 Benefit Cost Analysis

On the basis of public benefits and costs, the package of measures will deliver an increase in net economic welfare of almost $1.9 billion in FY2019 real dollars on central assumptions. This net figure comprises a present value of all quantifiable benefits of almost $3.5 billion, and a present value of costs of just over $1.6 billion. This creates a public BCR of 2.2 and a real internal rate of return on investment of 11% per annum – see Table 28. This indicates that the set of measures has been *highly* cost-effective, creating significant economic value at the same time as reducing greenhouse gas emissions and delivering other social benefits, such as reduced electricity network costs.

FY2019$m real, 4% real discount rate	Energy (incl. lighting)	Solar Hot Water	Totals
Public Benefits	$2,593	$883	$3,476
Public Costs	$977	$634	$1,611
NPV	$1,616	$249	$1,865
BCR	2.7	1.4	2.2
IRR	13%	9%	11%

Table 28: Summary of Public Costs and Benefits

Considering only those benefits and costs that fall on households, the package of measures has delivered net economic benefits of almost $1.3 billion, comprising a present value of private benefits of just under $2.7 billion and a present value of private costs of just under $1.4 billion. This represents a benefit cost ratio of 1.9 and a real internal rate of return on investment on the whole basket of measures of 11% - see Table 30.

	Units	Cumulative to 2058	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2058
Energy Savings														
6-star	TJ	81,659			1,052	2,041	2,041	2,041	2,041	2,041	2,041	2,041	989	252
Lighting	TJ	155			5	10	10	5						
Solar Hot Water	TJ	32,620	42	529	1,169	1,631	1,631	1,102	462					
Total:	TJ	**114,435**	**42**	**529**	**2,226**	**3,683**	**3,683**	**3,149**	**2,503**	**2,041**	**2,041**	**2,041**	**989**	**252**
Greenhouse Gas Emissions Savings														
6-star	t CO2-e	6,276,385			137,864	204,523	195,096	192,484	171,062	133,233	96,855	86,127	41,362	10,383
Solar Hot Water	t CO2-e	2,441,229	3,201	50,371	102,006	117,076	113,941	75,026	29,389					
Total	t CO2-e	**8,717,614**	**3,201**	**50,371**	**239,870**	**321,598**	**309,037**	**267,509**	**200,451**	**133,233**	**96,855**	**86,127**	**41,362**	**10,383**

Table 29: Summary of Resource and Emissions Savings: All Measures: Selected Years

FY2019$m real, 4% real discount rate	Energy (incl. lighting)	Solar Hot Water	Totals
Private Benefits	$1,832	$819	$2,651
Private Costs	$977	$420	$1,396
NPV	$855	$400	$1,255
BCR	1.9	2.0	1.9
IRR	8%	14%	11%

Table 30: Summary of Private Costs and Benefits

7.1.3 Industry Impacts

The impacts of these measures on industry have been assessed qualitatively through consultations with stakeholders; through our literature review; and via analysis of the quantitative data sets and simulation modelling results.

Key changes made to dwellings include lifting roof insulation from R4 – 5 to R5 – 6; lifting wall insulation levels from R1.5 – 2.0 to R2.0 – 2.5; some use of double in place of single glazing, and potentially low-emissivity glazing in more challenging applications, such as corner apartments.

The data available to the study does little to illuminate the 'learning rate', or rate of change over time in incremental costs. That is because information on actual construction costs incurred is held only by construction companies themselves, and there is no requirement or incentive for that data to be made public. Indeed, companies treat this data as confidential, as it is tightly linked to their profit margins. The costing analysis by Evissa Pty Ltd – described in Section 5.4 – indicates that the cost increases associated with the 6-star standard were modest for the designs modelled, while the benefit cost analysis indicates that costs were nearly doubled by the value of the community benefits delivered.

The key challenges (and therefore future opportunities) reported by stakeholders included the poor thermal properties of non-thermally-broken aluminium window frames, which remains the industry standard, and the non-availability of locally-made high-performance glazing, which causes reliance on imported product. Relatedly, the cost of high-performance glazing in Victoria, and elsewhere in Australia, was noted as highly discretionary from project to project, indicative of weak competition in this sector.

7.2 Conclusions

Overall, the package of measures has been both highly effective in generating significant resource and emissions savings; and highly cost-effective for consumers and the wider public benefit. Further, the savings and spillover benefits will be long-lived and continue to deliver value in coming decades. The combined net social benefit is estimated at just under $1.9 billion in today's dollars, with a BCR of 2.2 and an annual social return on investment of 11%. That is, the value of benefits has been significantly more than double the value of costs, while the social return is almost three times higher than Victoria's (applicable) real discount rate (4%), which is used to determine the threshold of cost-effectiveness. All elements of the package are cost-effective publicly as well as privately, and that cost-effectiveness is maintained through a wide range of sensitivity analyses.

Appendix A: Literature Review

Energy References

1. **Australian Greenhouse Office 2000, Impact of Minimum Performance Requirements for Class 1 Buildings in Victoria, Commonwealth of Australia, VIC.**

This report details the changes seen in the building of Class 1 dwellings in Victoria from the year 1990 to 1999/2000 due to mandatory minimum performance requirements within the Building Code of Australia (BCA); and in doing so analyses the effectiveness of this legislation in the reduction of household energy use, and therefore in greenhouse gas emissions. Dwellings studied include Class 1a(i): detached houses, and Class 1a(ii): attached dwellings (such as town houses), as detailed in the BCA. For these dwelling types, the report details energy consumption, emissions of greenhouse gases, construction techniques and building materials, as well as the application of solar passive design.

During the regulatory period of 1991 to 1999/2000, a total of 226,000 new houses were built in Victoria; 200,000 detached and 6,000 attached. A number of trends in the building of these dwelling were identified as contributing to an overall increase in thermal efficiency during this time period. There was an increase in the proportion of attached homes built (8% in 1990 to 15% in 1999), which were found to have an average thermal efficiency level 11% higher than detached houses sampled. The use of concrete flooring over this period increased by 5%, and was found, on average, to have a 14% higher thermal efficiency level than timber floors. A 28% improvement in thermal efficiency over the studied period can be attributed to increased insulation rates to comply with BCA regulations. There was a shift of 9% towards multi-storey housing, which was found to perform 14% better in terms of thermal efficiency than single-storey houses. There was also a shift towards the building of Class 1 homes in the relatively mild Melbourne climate zone, as opposed to more rural areas, accounting for approximately 1.8% improvement in thermal efficiency of the stock.

In conclusion, the average improvement in thermal efficiency over the course of the study period was approximately 40%; 36% of which occurred almost immediately after the implementation of the regulations in 1991. Between then and 1999/2000, only a 6% improvement was documented. Overall, the impact of BCA regulations introduced in 1991 was to limit the total state heating and cooling energy consumption to 75 PJ in 2000, a reduction of 9% compared to a scenario where they were not introduced. Similarly, impact of the regulations on greenhouse gas emissions was to limit them to 5.0 Mt in 2000, a reduction of 9% compared to a scenario without these regulations. The performance of Class 1 houses built during the regulatory period according to BCA regulations was, on average, equivalent to a 2.2 star rating.

2. **Centre for International Economics 2009, Final Regulation Impact Statement for residential buildings (Class 1, 2, 4 and 10 buildings) – Proposal to revise energy efficiency requirements of the Building Code of Australia for residential buildings, Australian Government, States and Territories of Australia, Canberra, ACT.**

This report is an assessment of the costs and benefits expected to be associated with changes to the energy efficiency requirements in the Building Code of Australia (BCA) for residential buildings; which at the time were due to be implemented in 2010. Nationally, costs and benefits to both individuals and society were found to be highly variable dependent on the discount rate used. In accordance with requirements of the Office of Best Practice Regulation, and following feedback from stakeholders, the report uses a final discount rate of 7 percent; which overall is projected to result in a net cost of approximately $259 million, and a benefit cost ratio (BCR) of 0.88, to the community nationally.

The report concludes that the estimated net impact on individual dwellings, estimated at a 7 percent discount rate, would be between a net benefit of around $6,400 to a net cost of around $2,400. This impact was calculated for thermal and lighting provisions only, for a typical house, and is dependent on location and compliance pathway. BCR estimates follow the same pattern as net impacts, ranging from 0.27 to 6.47 depending on compliance pathway, dwelling type and location. In terms of the Melbourne region, the present net value of the impact of thermal and lighting provisions on dwellings, at a 7 percent discount rate, was averaged at -$29 for houses, -$531 for townhouses and -$1337 for flats. The estimated BCR, under the same conditions, was calculated at 0.98 for houses, 0.61 for townhouses and 0.52 for flats.

Analysis undertaken for this regulation impact statement indicated that the proposed thermal and lighting changes together will reduce the residential building sector's annual greenhouse gas emissions by approximately 470 ktC02-e by the year 2020. Provisions for water heating could abate another 58 ktC02-e. Analysis of housing affordability measures indicated that, under initial estimates of costs and benefits, only marginal impacts on housing affordability are predicted as a result of planned amendments to the BCA. The report states that industry stakeholders raised concerns about the potential for additional building costs under the proposed requirements, suggesting the 1.25 percent initial estimate was too low; however, the extent of these extra costs are uncertain. Some stakeholders also argued that electricity and carbon prices may be underestimated in the analysis, although as projections these are also highly uncertain and dependent on outside influence. The issue of regional aggregations was also raised, and highlights the sensitivity of the BCR. Based on evidence available at the time this statement was written, the likely outcome of the final projections is that net costs will be imposed on major growth regions across the country, as well as a strong possibility that they will be imposed nationally.

3. **RMIT University 2012, Existing Buildings Research Project: Isolating opportunities for the improvement of the environmental performance of existing housing stock, Melbourne, VIC**

This report was designed to assess barriers to, and drivers of, the implementation of sustainability measures during residential renovation processes being undertaken in Victoria. Data was collected in the form of interviews with renovators who were either in the process of renovating or had completed a renovation within the past two years, with analysis of Australian Bureau of Statistics (ABS) and Valuer General of Victoria (VGV) data providing a broader context. Despite the significant presence of multi-unit residential dwellings in Victoria, only detached and semi-detached houses were studied. The voluntary nature of the survey resulted in a non-representational sample of building types as compared to the population, and was skewed towards older buildings (built in 1939 or earlier). According to previous research, the majority of Victorian housing stock is dated between 1960 and 1999.

The study found 69% of houses surveyed involved an extension to the existing dwelling. The average size of extensions was a 79% increase in floor area from the original building; though actual sizes ranged from 17% to a 220% increase in total floor area. Similarly, the average cost of an extension was found to be $175,676; however costs ranged from $20,000 to $650,000. Half of the renovators surveyed identified as 'owner builders', and were undertaking the renovation work personally. Of the dwellings sampled, insulation was present in 59.7% before, and 90.3% after, renovation; with roofing insulation increasing from 58% to 90%, wall insulation from 10% to 75% and floor insulation from 1% to 21%. This trend was relatively consistent across construction periods. The prevalence of double glazing increased from 0% before renovation, to 29% afterwards. The installation of water tanks also rose from 3% before to 47% following renovation.

Responses to survey questions identified a number of barriers to sustainable renovations, including: cost, lack of information and knowledge (including lack of cost/benefit analyses), capability of subcontractors (noting professional team issues) and the building or land not being suitable for renovation. Analysis also revealed the issues of achieving a sustainable renovation whilst expanding building size, and a lack of renovations being undertaken with buildings constructed since 1960, which represent almost 70% of Victorian housing stock. Renovators also identified a number of drivers towards sustainable renovation, such as a reduction in utility costs, improved comfort, positive feelings associated with incorporating a sustainable lifestyle and resale value.

The report details a number of recommended measures that could assist homeowners to implement sustainability practices in their renovations. It states that renovators tended to view sustainability measures as independent elements, in competition with other renovation elements, and therefore in competition with them for limited resources. It is suggested that overcoming the 'cost' barrier may be aided by shifting the way sustainability initiatives are seen, and situating them at the core of renovation objectives; by identifying sustainability measures that contribute to outcomes renovators see as important, and developing empirical measures and tools that allow renovators to assess and validate performance. Where extensions to houses are undertaken, sustainability outcomes tend to lessen or are fully offset, whereas renovations completed within the existing building plan have the potential to reduce energy and water use. Therefore, encouraging refurbishment of houses built after 1960, rather than older houses that tend to be smaller and undergo extensions, may achieve greater beneficial outcomes. Due to the presence of insulation, glazing and other features already in many of these homes, such refurbishments would require the development of customised solutions developed by experts, who would audit the houses of interested renovators. There have been examples of programs organised to this aim.

The 'cost barrier' may also be limited by the creation of a voluntary certification of house sustainability performance, before and after a renovation, which may be included as part of a sales disclosure and contribute to the value of the house. Considering there are numerous sources of quality, though general, information obtainable online on sustainability initiatives, what renovators may benefit from is a manual identifying the intricacies of their particular type of house; for example, it is suggested that a set of manuals for Victoria be developed around case studies. At the policy level, the report suggests that interventions be spatially informed, allowing for consideration of both most common housing type and local climatic conditions. In conclusion, the report states that in itself it only partially explains how sustainability plays into the socio-techno system of renovation and renovators; and that further exploration of measures to assist homeowners implement sustainable practices would represent a worthwhile investment.

4. **Pitt & Sherry 2013, Environmentally efficient design planning policies – cities of Banyule, Moreland, Port Phillip, Stonnington, Whitehorse and Yarra; Expert evidence – Benefit Cost Analysis, Hobart, TAS.**

This report details the costs and benefits associated with the Environmentally Efficient Design (EED) planning policies that are proposed to be included in the Council planning schemes of Banyule, Port Phillip, Yarra, Whitehorse and Moreland. Although specifics of policies differ across councils, they each contain eight performance dimensions; namely energy efficiency, water efficiency, indoor environmental quality, stormwater management, waste management, urban ecology, transport and innovation. The aim of these policies is to effect changes at the building design stage to avoid future costs, by encouraging developers to consider these environmental dimensions early in the development process; as well as strive for 'best practice' in each of the eight areas.

The report concludes that each of the four building/development types examined – small multi-dwelling residential buildings, small residential extensions, large multi-unit residential buildings and small commercial buildings – show a clear net benefit when EED policies are applied, as opposed to a scenario in which they are not. The results, that the present value of benefits exceeds those of costs (at a 7 percent discount rate) by between 3.1 and 6.8 times over a simple payback period of between 4.9 and 1.8 years, can be classed as 'highly' to 'extremely cost-effective' at the upper end of the benefit cost ratio (BCR). Further, sensitivity analysis suggests that the EED policies are likely to remain cost-effective across plausible variations in real discount rates, building sizes (at the upper end of the range) and carbon price outlooks.

Key matters, from a benefit cost analysis perspective, addressed in the report include: administration costs, compliance costs, building lifestyle costs, avoidance of future retrofit costs and additional regulatory cost burdens. Costs associated with each of these matters were found to be reasonable, and in general, outweighed by predicted future benefits – either monetary, social or both. A minority of submissions to the report raised issues related to the benefits and costs of the proposed policies. These matters include: additional cost burdens, concerns requirements should be proportional, uncertainty about costs and benefits, variations in requirements between Councils, the definition of 'best practice', sufficiency or superiority of current Building Code of Australia (BCA) requirements and additional costs for 'reuse' or 'mixed use' buildings. The report addresses each of these concerns, finding that additional costs, if any, are substantially outweighed by the value of benefits, that requirements and variations should be evidence-based and that current mandatory minimum requirements under BCA provisions for energy efficiency are not socially optimal. The report itself addresses other issues listed. Overall, this report concludes that implementation of EED planning policies for the participating councils would be highly cost-effective.

5. **The Allen Consulting Group 2013, Benefit-cost analysis of proposed BASIX stringency changes, Report to the NSW Department of Planning and Infrastructure, Sydney, NSW.**

This report provides a benefit cost analysis (BCA) of proposed changes to the Building Sustainability Index (BASIX), a scheme introduced by the NSW Government in 2004 to regulate the water and energy efficiency of residential buildings. The major proposed changes are an increase in both the energy and water targets, and an increased stringency regarding thermal comfort to comply with current national standards.

The BCA is focused on the community as a whole, and costs and benefits are considered to be incremental. The analysis employs twelve representative dwelling types, including: detached houses, high-rise apartment blocks, an attached house and a low-rise apartment complex. All building types were found to have positive returns, except two. The best performing dwellings were those with alternative compliance pathways (combinations of air conditioning and fan) and small unit blocks (a 3 or 13 unit development); each having a benefit cost ratio (BCR) in excess of 1.5, indicating a very positive return for the household. Two dwelling types were found to have a negative BCR, namely households with gas or solar hot water (0.74) and medium sized unit blocks (0.76, based on a 37 unit development). In these instances, compliance costs were greater than lifetime water and energy savings.

Statewide, water and energy savings in NSW can be expected to reach a considerable amount over the next decade due to the expected increase in housing stock by around 400,000 dwellings. Key benefits to the community are expected to take the form of improved efficiency of household energy and water consumption, health improvements, savings in greenhouse gas emissions and indirect market benefits, such as stimulus to sustainable design businesses. The proposed incremental increase in stringency to the BASIX policy is expected to provide a net benefit of around 510 billion dollars to the community, with a BCR of 1.64. In terms of housing affordability, implementation of proposed changes may lead to a slight increase in housing prices, as sellers seek to recoup costs of complying with BASIX; however, these costs are likely to be offset by a reduction in household costs as a result of reduced utility bills from improved energy and water efficiency. Overall, this report concludes that the proposed changes to BASIX policy can be implemented at a negative cost; with the outcomes being positive for both individual households and the NSW community at large. The incremental nature of the proposed changes means costs to government and industry are expected to be very limited.

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

This project report aims to identify how the residential buildings sector has responded to the introduction of the 6-star energy efficiency standard, implemented as changes to the Building Code of Australia in 2010, and how these responses have changed over time. Research was conducted in two forms: a qualitative component, including interviews with stakeholders and survey responses from across the building industry; and a quantitative component, based on a sample of representative dwellings obtained from the industry.

Qualitative research responses indicated the initial primary change, in response to the 6-star equivalent energy efficiency requirements, was to increase the level of specification in glazing and insulation. Industry respondents agreed there was an added cost associated with the introduction of these requirements, though the amount varied. Thirty-four percent indicated initial cost was neutral or less than $2,000, 36% indicated it was between $2,000 and $5,000, and 30% that the cost increase was over $5,000. Stakeholders noted that costs could be decreased through better management and industry learning over time. Planning regulations and macro-economic issues were also highlighted as significant determinants of cost.

Quantitative research findings indicated that, when looking at voluntary improvements beyond six star, area-adjusted cost of Class 1 dwellings was $18/sqm, and Class 2 was $7/sqm. However, the confidence in this analysis is relatively low, due to the high variability of dwelling costs. An annual industry learning rate of 7.5% was found over the 2014-2017 period (7.1% for Class 1 dwellings and 1.7% for Class 2). These learning rates and incremental costs indicate that at least a 7-star rating should be cost-effective from 2020, the assumed first year of application of a possible new energy efficiency standard for residential buildings in Australia.

7. **Department of Environment, Land, Water and Planning 2018, Housing outcomes in established Melbourne 2015 to 2016 – Monitoring land use planning outcomes, Department of Environment, Land, Water and Planning, East Melbourne, VIC.**

This report profiles 12 years of housing development activity across metropolitan Melbourne, from 2005 to 2016. It details that this period has been one of increased residential construction across all dwelling types and locations: growth area houses, middle and outer suburb houses, middle and outer suburb semi-detached and low-rise apartments, middle high rise apartments and inner high rise apartments. The total number of dwelling approvals in Greater Melbourne almost doubled from around 27,000 in 2005 to around 58,000 in 2017.

8. **ASBEC 2018, Built to Perform: An industry led pathway to a zero carbon ready building code, Australian Sustainable Built Environment Council and Climate Works, Jul 2018**

This recent report shows that lifting energy standards for new buildings in the National Construction Code could, between now and 2050, reduce energy bills by up to $27 billion, cut energy network costs by up to $7 billion and deliver at least 78 million tonnes of cumulative emissions savings.

Solar Hot Water References

1. **ABCB 2016, National Construction Code 2016: Volume 2: Building Code of Australia Class 1 and Class 10 Buildings, Australian Building Codes Board, Feb 2016**

A state specific variation for Victoria to section 3.12.0(a) provides for the Performance Requirement P2.6.1 for the thermal performance of the building to be satisfied by (*inter alia*) "in the case of a new Class 1 building, having either a rainwater tank connected to all sanitary flushing systems, or a solar water heater system, installed in accordance with the Plumbing Regulations 2008".

2. **VicGov 2004, Plumbing (Water and Energy Savings) Regulations 2004**

These regulations define what a solar hot water system is and what a rainwater tank is for the purpose of the plumbing regulations.

3. **Wilkenfeld 2006, Water Saving Requirements for New Residential Buildings in Victoria: Options for flexible compliance, George Wilkenfeld and Associates Pty Ltd, Jun 2006**

Investigates the options for performance-based alternatives to the (then) current Victorian water and energy saving measures which included low flow shower heads and taps, a limit on water supply pressure and the requirement for either a solar or heat pump water heater or a rainwater tank. A performance-based approach means that water savings measures and techniques would be assessed on the likely amount of water savings through water conservation, reuse or recycling, rather than prescribing a particular product type. The study develops a model (p.5) of the assumed savings from current measures (35.8 kl/yr for an average sized Class 1 dwelling). Performance based measures would need to meet or exceed these savings.

"Even though the present regime may not have been the most effective and cost-effective means of pursuing both water-saving and greenhouse-reducing objectives for new homes in Victoria, it has the advantage of simplicity and familiarity. Transition to a performance-based regime which achieves equivalent water and greenhouse savings at equal or lower cost will not be a simple matter. There may be some arguments for leaving the regime as it is." p.8

Conclusion 6: "A performance-based approach would be more complex, for both governments and home building applicants, than the current 5-star approach. There is a need for appropriate 'program elements' to support policy-makers and administrators, and for appropriate 'public elements' to assist building applicants, homebuilders and product suppliers." p.11

p.5 useful categorization and description of types of risks in choosing program measures: Compliance risk, performance risk, persistence risk.

p.7 discussion of interaction between emissions reduction and water saving from efficient hot water options.

“The ‘5-star’ thermal performance requirements and the water and energy saving measures were phased in between 1 July 2004 and 1 July 2005. During that period various combinations of thermal performance rating and water saving measures were permitted, as set out in the Building Commission Practice Notes 2004-55 and 2005-55. A further variation was the acceptance of connection to a dual-pipe recycled water supply (where available), plumbed to all sanitary flushing fixtures plus outdoor supply, as an alternative to a rainwater tank for Class 1 dwellings.“ p.17

4. **pitt&sherry 2013, Environmentally Efficient Design Planning Policies – Cities of Banyule, Moreland, Port Phillip, Stonnington, Whitehorse and Yarra – Expert Witness Report – Philip Harrington**

The report focuses on the benefits and costs attributable to the Environmentally Efficient Design (EED) planning policies that are proposed to be incorporated within the planning schemes of the Moreland, Port Phillip, Yarra, Stonnington, Banyule and Whitehorse councils. Quantitative analysis was undertaken with reference to four representative building/development types that are commonly found in each of the Joint Council areas. Sensitivity analyses was carried out and demonstrated that the cost-effectiveness of the EED policies is very little affected by changes in discount rates, carbon prices or scale of development.

Each of the four building/development types examined shows a clear net benefit where the EED policies are applied. The present value of benefits (at a 7% real discount rate) exceeds the present value of costs by between 3.1 and 6.8 times.

5. **Allen 2004, Enhancing 5-Star Home Energy Standards in Victoria – a benefit-cost analysis of prospective water efficiency, rainwater tank and solar hot water heating regulations, The Allen Consulting Group, Feb 2004**

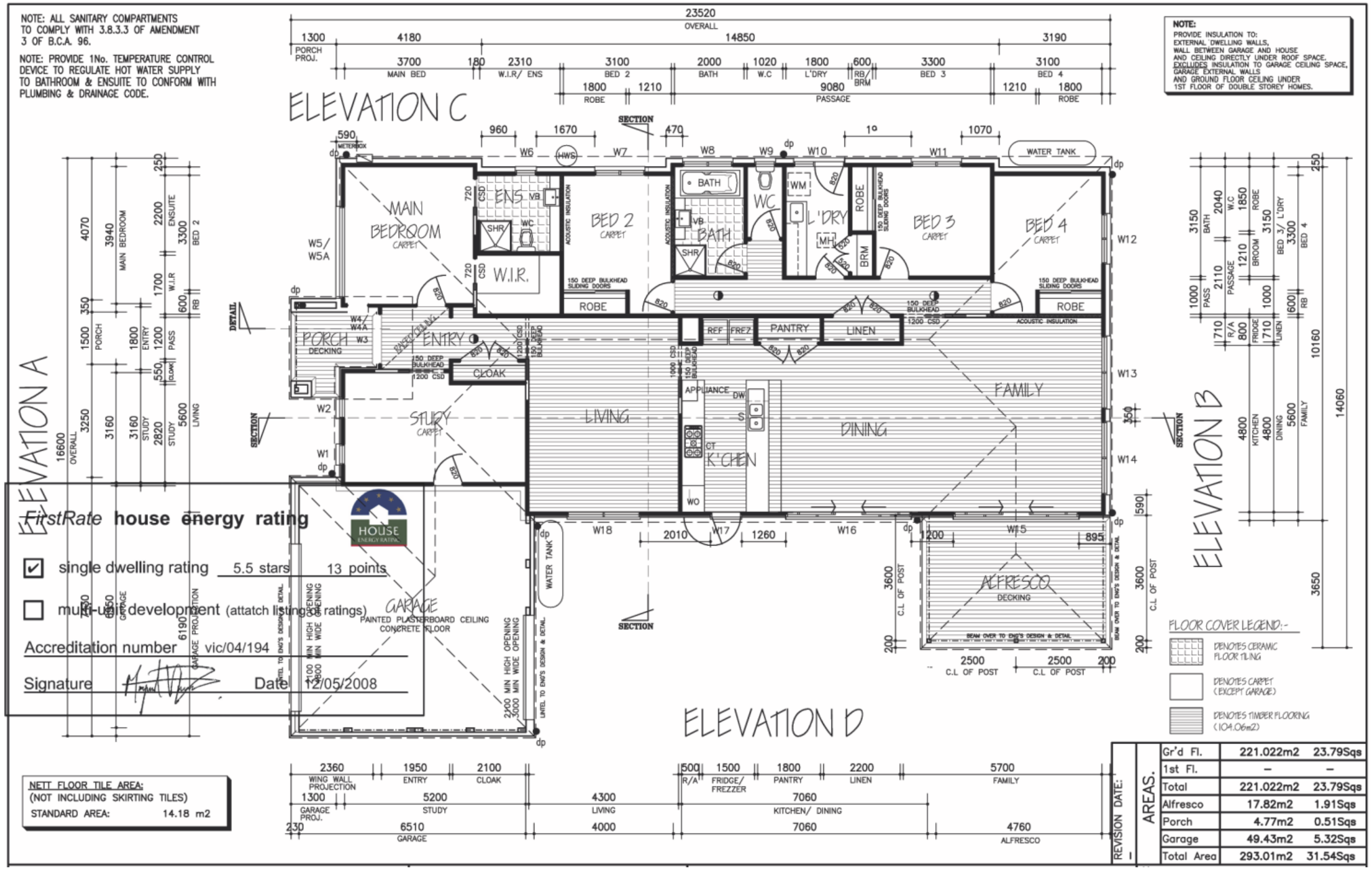
The purpose of this study was to provide the Victorian Government with an analysis of the benefits and costs of enhancing the 5-Star regulation standard with proposed additional energy efficiency measures. The proposed measures are energy/water efficient plumbing fittings, and either a solar hot water heater or rainwater tank for toilet flushing. Six scenarios were modelled and assessed relative to a business as usual (base case) scenario using three criteria: increased energy efficiency, economic and social benefits and reduction of ghg emisssions. By all criteria, the greatest benefits were provided by the 5-Star, water efficient plumbing and solar hot water heater.

The study findings also suggest…that the effects of the introduction of the 5-Star energy rating, water-efficient plumbing and rainwater tank regulation standard into Victorian housing are such that Victoria would be better off in economic welfare terms under the 5-Star plus water efficient plumbing scenario or the 5-Star standard alone. By most measures the water tank scenario yields a less favourable outcome than would occur under the 5-Star energy, water-efficient plumbing and solar hot water standard, and in the long run is expected to return less to the Victorian economy than a 5-Star standard (scenario 1). It is important to note, however, that this finding is based on the present price of water and a business-as-usual projection of that price into the future. It is quite possible that this price, and the consequent savings to consumers, under-values the benefits of saving water in future years, when the population will be greater and the availability of water may be reduced. p.9

6. **Allen 2013, Benefit-cost analysis of proposed BASIX stringency changes, The Allen Consulting Group, 23 Jul 2013**

The Building Sustainability Index (BASIX) was introduced in 2004 by the NSW Government to regulate the energy and water efficiency of residential buildings. This report to NSW Department of Planning and Infrastructure assesses the cost/benefit of increasing stringency settings for energy efficiency, water savings and thermal comfort. Benefits were assessed only in terms of cost savings for water, gas and electricity but the report notes (p.x) that there are additional non-market benefits such as health improvements and ghg reductions. On balance, the increase in the proposed BASIX stringency provides a net benefit to the community of around half a billion dollars. The BCR of this incremental policy change is 1.64.

Single-storey house



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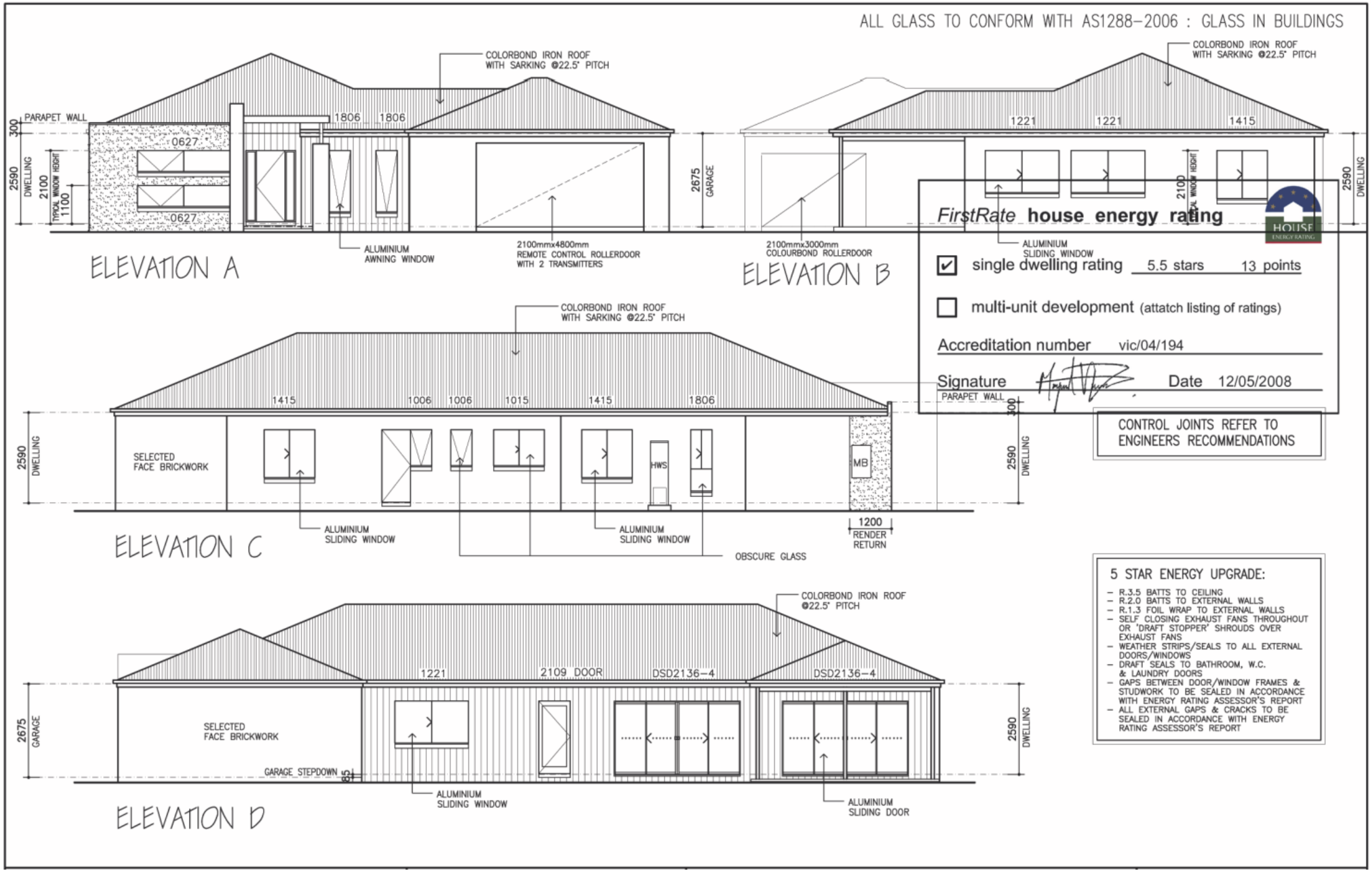
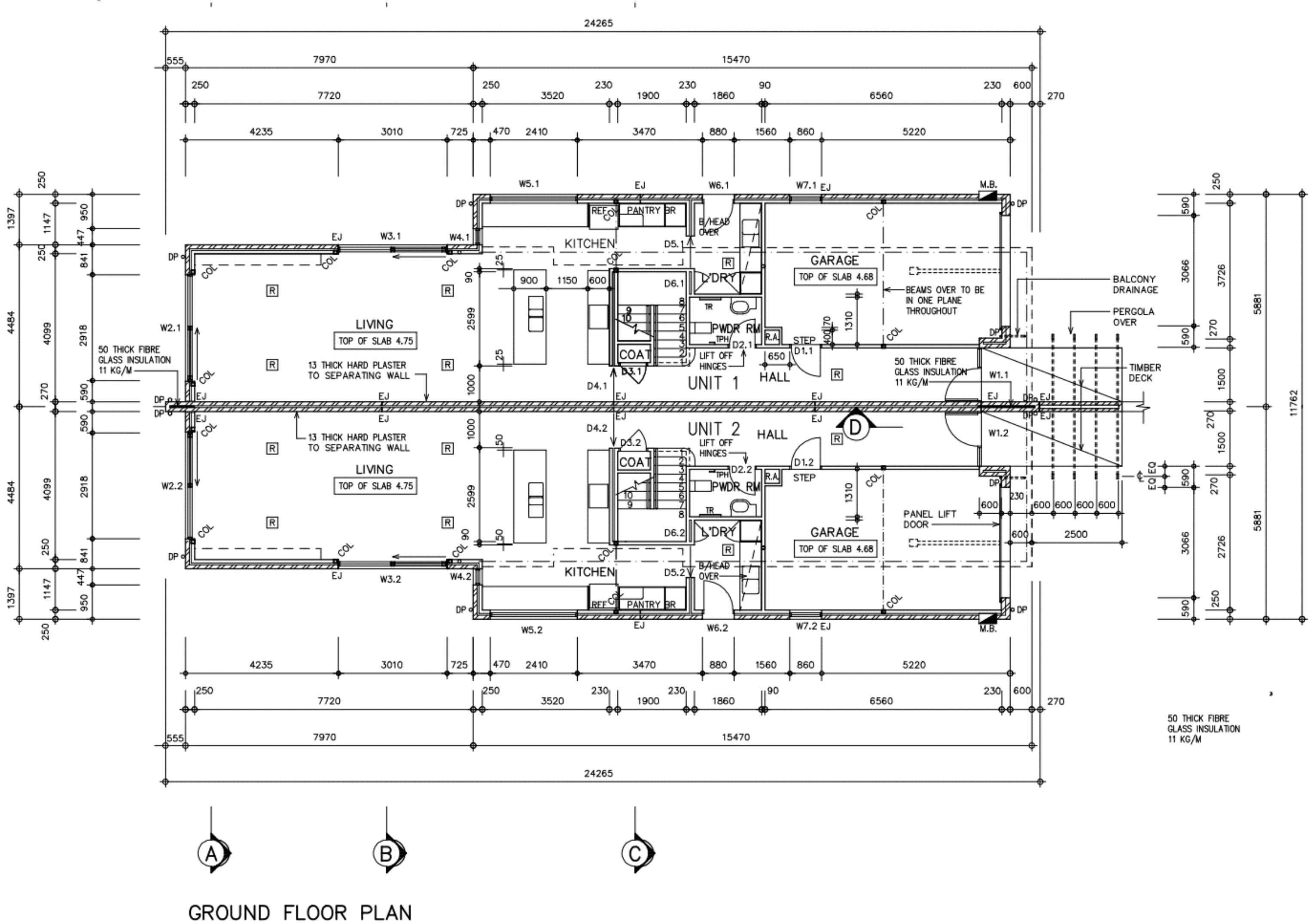


ALL GLASS TO CONFORM WITH AS1288–2006 : GLASS IN BUILDINGS
COLORBOND IRON ROOF WITH SARKING @22.5° PITCH
PARAPET WALL
ALUMINIUM AWNING WINDOW
2100mmx4800mm REMOTE CONTROL ROLLERDOOR WITH 2 TRANSMITTERS
ELEVATION A
2100mmx3000mm COLOURBOND ROLLERDOOR
ALUMINIUM SLIDING WINDOW
ELEVATION B
FirstRate house energy rating
single dwelling rating 5.5 stars 13 points
multi-unit development (attatch listing of ratings)
Accreditation number vic/04/194
Signature
Date 12/05/2008
CONTROL JOINTS REFER TO ENGINEERS RECOMMENDATIONS
SELECTED FACE BRICKWORK
ALUMINIUM SLIDING WINDOW
OBSCURE GLASS
1200 RENDER RETURN
ELEVATION C
5 STAR ENERGY UPGRADE:
– R.3.5 BATTS TO CEILING
– R.2.0 BATTS TO EXTERNAL WALLS
– R.1.3 FOIL WRAP TO EXTERNAL WALLS
– SELF CLOSING EXHAUST FANS THROUGHOUT OR 'DRAFT STOPPER' SHROUDS OVER EXHAUST FANS
– WEATHER STRIPS/SEALS TO ALL EXTERNAL DOORS/WINDOWS
– DRAFT SEALS TO BATHROOM, W.C. & LAUNDRY DOORS
– GAPS BETWEEN DOOR/WINDOW FRAMES & STUDWORK TO BE SEALED IN ACCORDANCE WITH ENERGY RATING ASSESSOR'S REPORT
– ALL EXTERNAL GAPS & CRACKS TO BE SEALED IN ACCORDANCE WITH ENERGY RATING ASSESSOR'S REPORT
COLORBOND IRON ROOF @22.5° PITCH
2109 DOOR
DSD2136–4
GARAGE STEPDOWN
ALUMINIUM SLIDING WINDOW
ALUMINIUM SLIDING DOOR
ELEVATION D

Two-storey townhouse



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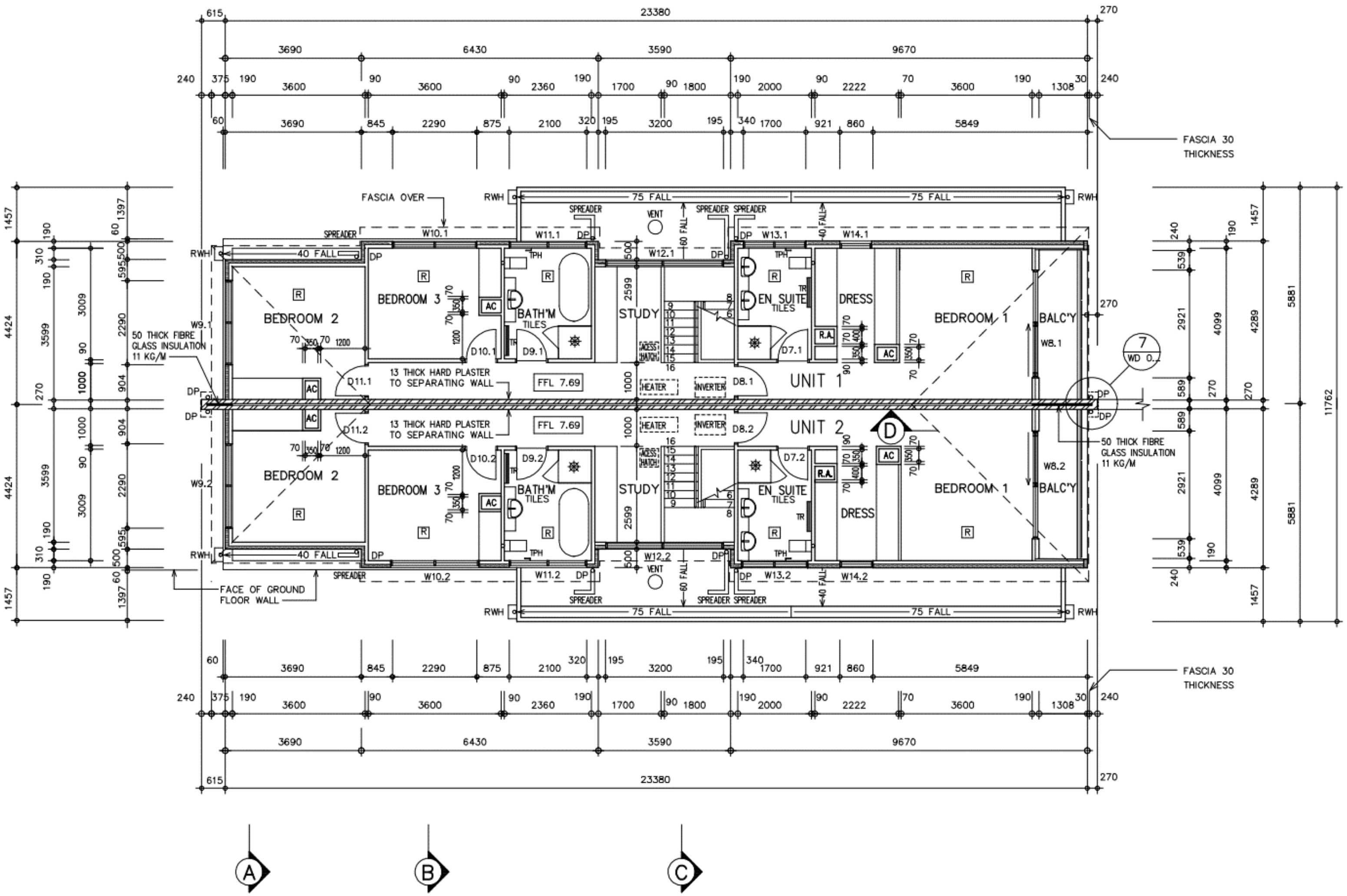
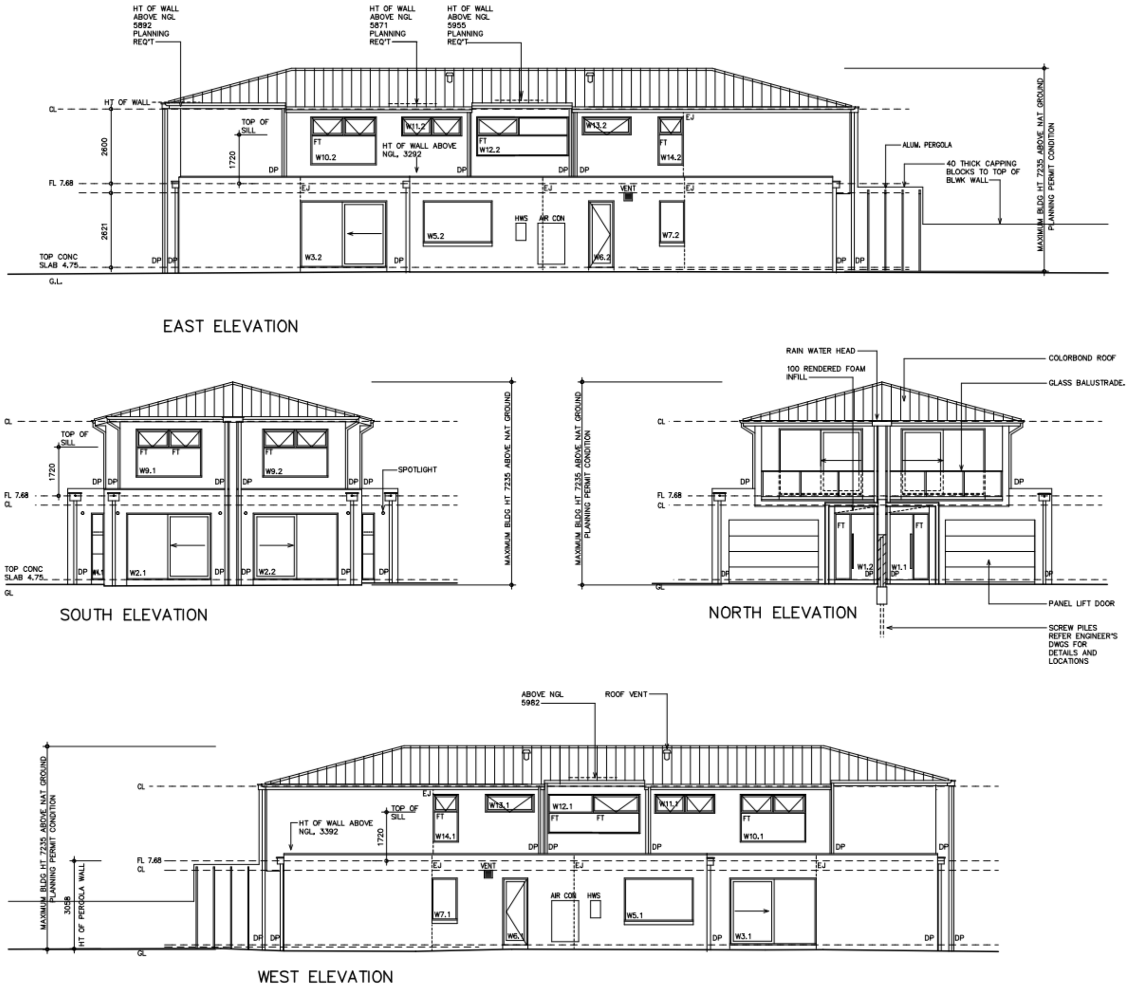


FIRST FLOOR PLAN



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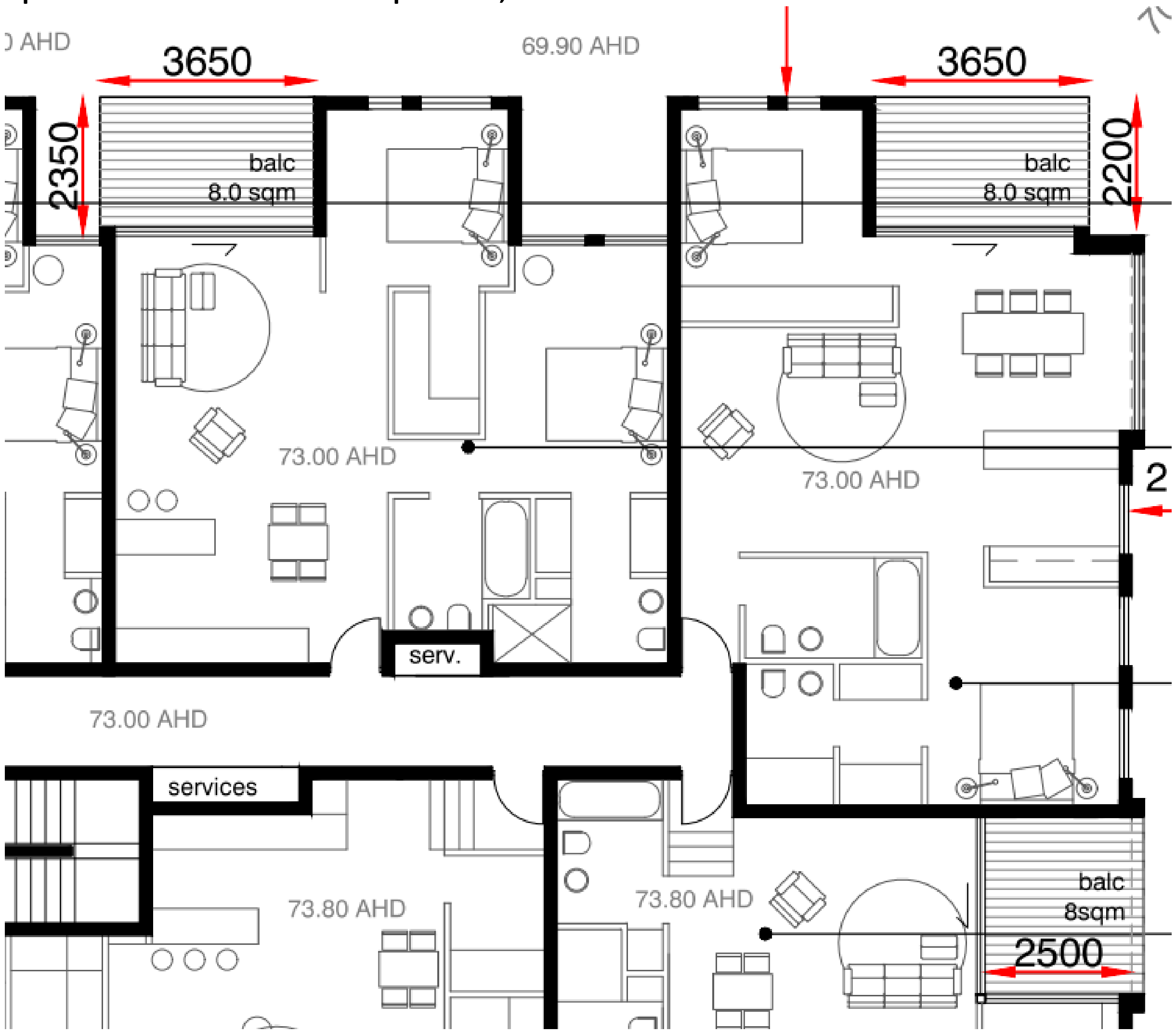
Apartments – middle and corner positions, mid-level.



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EAST ELEVATION

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Single Story Class 1 – Climate Zone 62 Moorabbin (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door North	5.0	164.4	151.2	13.2	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.0 bulk Insulation Fibre cement cladding walls: R 2.0 bulk Insulation Internal garage walls shared with dwelling: R 2.0 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.1	122.1	107.4	14.7	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	as above	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining & family sliding doors	43.75	22.4%
	6.5	106.8	93.9	13.0	195.5	241.8	as above	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door	43.75	22.4%

Single Story Class 1 – Climate Zone 62 Moorabbin (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door East	5.1	162.6	147.8	14.8	195.5	241.8	Concrete slab	Brick Veneer Walls: R 1.5 bulk Insulation Fibre cement cladding walls: R 1.5 bulk Insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	R 3.5 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.1	122.2	104.9	17.3	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.5	106.6	92.0	14.6	195.5	241.8	as above	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining / family sliding doors, kitchen hinge door and family sliding windows	43.75	22.4%

Single Story Class 1 – Climate Zone 62 Moorabbin (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door South	5.1	162.1	147.6	14.5	195.5	241.8	Concrete slab	Brick Veneer Walls: R 1.5 bulk Insulation Fibre cement cladding walls: R 1.5 bulk Insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	124.8	107.0	17.8	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.5	107.3	93.4	13.9	195.5	241.8	as above	as above	as above	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining / family sliding doors, kitchen hinge door and family, living, bedroom 2, bedroom 3, bedroom 4 sliding windows	43.75	22.4%

Single Story Class 1 – Climate Zone 62 Moorabbin (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door West	5.0	164.8	152.5	12.3	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.0 bulk Insulation Fibre cement cladding walls: R 2.0 bulk Insulation Internal garage walls shared with dwelling: R 2.0 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	124.2	109.4	14.8	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Family sliding door	43.75	22.4%
	6.5	107.6	96.1	11.5	195.5	241.8	as above	as above	as above	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door	43.75	22.4%

Single Story Class 1 – Climate Zone 60 Tullamarine (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door North	5.1	179.3	161.3	18.0	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.1	135.6	116.5	19.1	195.5	241.8	Waffle Pod 300-85 (R 0.8)	as above	as above	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining / family sliding doors and family sliding windows	43.75	22.4%
	6.5	117.7	101.3	16.4	195.5	241.8	as above	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Timber framed clear double glazed laundry door Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Dining / family sliding doors and family sliding windows	43.75	22.4%

Single Story Class 1 – Climate Zone 60 Tullamarine (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door East	5.1	117.9	159.0	18.9	195.5	241.8	Concrete slab	Brick Veneer Walls: R 1.5 bulk Insulation Fibre cement cladding walls: R 1.5 bulk Insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	R 3.5 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	136.5	113.5	23.0	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.5	116.9	99.0	17.9	195.5	241.8	as above	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining / family sliding doors, kitchen hinge door and family, living, bedroom 3, bedroom 4 sliding windows	43.75	22.4%

Single Story Class 1 – Climate Zone 60 Tullamarine (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door South	5.0	181.2	163.5	17.8	195.5	241.8	Concrete slab	Brick Veneer Walls: R 1.5 bulk Insulation Fibre cement cladding walls: R 1.5 bulk Insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	R 4.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	136.8	115.9	20.9	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Family sliding windows	43.75	22.4%
	6.6	116.0	99.8	16.2	195.5	241.8	as above	as above	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door	43.75	22.4%

Single Story Class 1 – Climate Zone 60 Tullamarine (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door West	5.0	181.2	167.6	13.6	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.0 bulk Insulation Fibre cement cladding walls: R 2.0 bulk Insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.1	134.4	118.8	15.6	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	as above	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining / family sliding doors	43.75	22.4%
	6.5	117.8	105.1	12.6	195.5	241.8	as above	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door	43.75	22.4%

Single Story Class 1 – Climate Zone 66 Ballarat (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door North	5.0	255.1	237.3	17.8	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	195.8	175.7	20.1	195.5	241.8	Waffle Pod 300-85 (R 0.8)	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining & family sliding doors	43.75	22.4%
	6.5	167.7	150.6	17.1	195.5	241.8	as above	as above	as above	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door Aluminium framed clear double glazed Low-e: Dining / family sliding doors & family sliding windows	43.75	22.4%

Single Story Class 1 – Climate Zone 66 Ballarat (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door East	5.0	255.8	237.5	18.3	195.5	241.8	Concrete slab	Brick Veneer Walls: R 1.5 bulk Insulation Fibre cement cladding walls: R 1.5 bulk Insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	R 4.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	196.9	174.1	22.7	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.5	167.7	150.5	17.2	195.5	241.8	as above	as above	as above	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining / family sliding doors, kitchen hinge door and family, living, bedroom 1, bedroom 3, bedroom 4, study windows	43.75	22.4%

Single Story Class 1 – Climate Zone 66 Ballarat (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area
		Total	Heating	Cooling								
Entry Door South	5.0	256.7	238.9	17.7	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.0 bulk Insulation Fibre cement cladding walls: R 2.0 bulk Insulation Internal garage walls shared with dwelling: R 2.0 bulk insulation	R 3.5 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75
	6.1	193.9	173.1	20.8	195.5	241.8	Waffle Pod 300-85 (R 0.8)	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining sliding door	43.75
	6.5	167.0	150.7	16.4	195.5	241.8	as above	as above	as above	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door	43.75

Single Story Class 1 – Climate Zone 66 Ballarat (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door West	5.1	252.4	239.2	13.3	195.5	241.8	Concrete slab	Brick Veneer Walls: R 2.5 bulk Insulation Fibre cement cladding walls: R 2.5 bulk Insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	R 5.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door	43.75	22.4%
	6.0	195.2	179.0	16.2	195.5	241.8	Waffle Pod 300-85 (R 0.8)	as above	as above	AWS	Aluminium framed clear single glazed Timber framed clear single glazed laundry door Aluminium framed clear double glazed: Dining & family sliding doors	43.75	22.4%
	6.5	168.4	155.7	12.7	195.5	241.8	as above	as above	R 6.0 bulk ceiling insulation (excluding garage) + sarking to underside of metal roof	AWS	Aluminium framed clear double glazed Timber framed clear double glazed laundry door Aluminium framed clear double glazed Low-e: Family sliding door	43.75	22.4%

Semi-detached 2 Level Townhouse – Climate Zone 62 Moorabbin (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door North	5.1	162.0	140.9	21.1	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 2.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.0 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.0 bulk insulation Internal garage walls shared with dwelling: R 2.0 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	123.5	106.8	16.7	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber	as above	as above	AWS	Aluminium framed clear double glazed	45.29	31.8%
	6.5	106.7	90.5	16.2	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear double glazed Aluminium framed clear double glazed argon filled Low-e: Dining & living sliding doors	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 62 Moorabbin (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door East	5.0	163.1	137.9	25.2	142.2	163.5	Ground Level: Concrete slab Level 1: Timber; R 2.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 1.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 1.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	125.0	100.5	24.5	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	as above	AWS	Aluminium framed clear single glazed Aluminium framed clear double glazed: Dining & living sliding doors	45.29	31.8%
	6.5	107.3	85.1	22.2	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2 window	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 62 Moorabbin (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door South	5.0	164.1	144.6	19.5	142.2	163.5	Ground Level: Concrete slab Level 1: Timber	Ground Level Brick Veneer Walls: R 1.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 1.5 bulk insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 2.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	123.7	104.4	19.3	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed clear double glazed: Dining & living sliding doors	45.29	31.8%
	6.5	107.5	89.9	17.6	142.2	163.5	as above	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 5.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2 & bedroom 3 windows	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 62 Moorabbin (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door West	5.0	164.1	146.3	17.8	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1 Timber: R 3.5 bulk insulation to underside of level 1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	124.7	110.8	14.0	142.2	163.5	as above	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 5.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2, bedroom 3, study windows & bedroom WIR windows	45.29	31.8%
	6.5	107.5	94.4	13.1	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear double glazed Aluminium framed clear double glazed argon filled Low-e: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 60 Tullamarine (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	**Heating**	**Cooling**									
Entry Door North	5.0	180.7	158.8	21.9	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber	Ground Level Brick Veneer Walls: R 2.0 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.0 bulk insulation Internal garage walls shared with dwelling: R 2.0 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	136.1	118.4	17.6	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear double glazed	45.29	31.8%
	6.5	116.3	99.4	16.9	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear double glazed Aluminium framed clear double glazed argon filled Low-e: Dining & living sliding door. Kitchen fixed window	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 60 Tullamarine (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door East	5.1	178.5	150.7	27.8	142.2	163.5	Ground Level: Concrete slab Level 1: Timber	Ground Level Brick Veneer Walls: R 1.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 1.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 2.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.1	135.6	107.3	28.2	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed clear double glazed: Dining & living sliding doors	45.29	31.8%
	6.5	116.4	90.8	25.5	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2 window	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 60 Tullamarine (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door South	5.1	175.6	155.6	20.0	142.2	163.5	Ground Level: Concrete slab Level 1: Timber	Ground Level Brick Veneer Walls: R 1.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 1.5 bulk insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 2.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.1	134.2	114.6	19.6	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed clear double glazed: Dining & living sliding doors, kitchen fixed window	45.29	31.8%
	6.5	116.9	99.3	17.6	142.2	163.5	as above	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2 & bedroom 3 windows	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 60 Tullamarine (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	**Heating**	**Cooling**									
Entry Door West	5.0	181.2	162.7	18.5	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1 Timber: R 3.5 bulk insulation to underside of level 1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.1	134.8	121.9	12.9	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear double glazed	45.29	31.8%
	6.5	118.0	105.8	12.2	142.2	163.5	as above	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 5.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear double glazed Aluminium framed clear double glazed argon filled Low-e: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2 window	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 66 Ballarat (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door North	5.1	251.6	225.3	26.3	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 2.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.0 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.0 bulk insulation Internal garage walls shared with dwelling: R 2.0 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.1	191.3	169.8	21.5	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear double glazed	45.29	31.8%
	6.5	168.2	147.0	21.2	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 5.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear double glazed Aluminium framed clear double glazed argon filled Low-e: Dining & living sliding doors, kitchen fixed window	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 66 Ballarat (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door East	5.0	253.9	224.5	29.5	142.2	163.5	Ground Level: Concrete slab Level 1: Timber; R 2.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 1.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 1.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	195.4	165.3	30.1	142.2	163.5	as above	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	as above	AWS	Aluminium framed clear single glazed Aluminium framed clear double glazed: Dining & living sliding doors	45.29	31.8%
	6.6	165.6	139.3	26.3	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2, bedroom 3 & study windows	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 66 Ballarat (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door South	5.0	254.5	235.2	19.3	142.2	163.5	Ground Level: Concrete slab Level 1: Timber	Ground Level Brick Veneer Walls: R 1.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 1.5 bulk insulation Internal garage walls shared with dwelling: R 1.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 2.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	195.8	176.6	19.1	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1: Timber; R 3.5 bulk insulation to underside of level1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 4.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed Aluminium framed clear double glazed: Dining & living sliding doors	45.29	31.8%
	6.5	166.5	149.3	17.2	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2, bedroom 3 & study windows	45.29	31.8%

Semi-detached 2 Level Townhouse – Climate Zone 66 Ballarat (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Area + Garage	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling									
Entry Door West	5.1	249.8	230.7	19.1	142.2	163.5	Ground Level: Waffle Pod 300-85 (R 0.8) Level 1 Timber: R 3.5 bulk insulation to underside of level 1 floor shared with garage below	Ground Level Brick Veneer Walls: R 2.5 bulk Insulation Level 1 - 75mm Polystrene Walls: R 2.5 bulk insulation Internal garage walls shared with dwelling: R 2.5 bulk insulation	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 3.5 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear single glazed	45.29	31.8%
	6.0	196.9	181.9	15.0	142.2	163.5	as above	as above	as above	AWS	Aluminium framed clear single glazed Aluminium framed Clear double glazed: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window, bedroom 2, bedroom 3 & study windows	45.29	31.8%
	6.5	167.7	153.5	14.1	142.2	163.5	as above	as above	Ground level: R 2.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof (excluding garage) Level 1: R 5.0 bulk ceiling insulation + Anticon 60 R 1.3 to underside of metal roof	AWS	Aluminium framed clear double glazed Aluminium framed clear double glazed argon filled Low-e: Dining, living & bedroom 1 sliding doors, kitchen fixed & double hung window	45.29	31.8%

Middle 2 Bedroom Apartment – Climate Zone 21 Melbourne (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony North	5.9	116.7	98.5	18.2	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.3	105.1	87.5	17.5	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.9	87.1	72.8	14.3	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 21 Melbourne (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony East	5.1	144.7	120.4	24.4	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	113.8	93.6	20.2	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.7	93.0	75.6	17.4	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony)	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 21 Melbourne (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony South	5.1	146.3	131.8	14.5	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	112.5	101.2	11.3	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.6	95.1	84.7	10.4	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 21 Melbourne (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony West	5.1	145.4	121.5	23.9	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	112.9	93.7	19.2	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.5	96.5	77.8	18.8	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 62 Moorabbin (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony North	5.6	138.5	125.4	13.1	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	124.5	111.7	12.7	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.6	104.0	93.2	10.7	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 62 Moorabbin (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony East	5.1	162.7	144.6	18.0	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	124.7	109.9	14.8	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.7	100.3	87.9	12.5	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony)	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 62 Moorabbin (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony South	5.2	155.3	144.6	10.6	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	123.8	115.8	8.0	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.7	102.6	95.6	7.0	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony)	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 62 Moorabbin (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony West	5.3	150.9	132.8	18.2	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.2	119.4	104.1	15.3	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e: Sliding door (balcony) Aluminium framed clear double glazed: Awning (bedroom1 & 2) Aluminium framed clear double glazed: Fixed (bedroom1 & 2)	19.98	28.7%
	6.5	106.7	92.5	14.2	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 66 Ballarat (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony North	5.7	215.2	203.9	11.3	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	194.4	183.1	11.3	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.6	165.3	156.4	8.8	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 66 Ballarat (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony East	5.2	244.3	228.3	16.0	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.1	194.2	181.4	12.8	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.7	159.8	149.2	10.6	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony)	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 66 Ballarat (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony South	5.0	255.9	247.8	8.0	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.1	191.0	184.8	6.2	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.5	97.3	86.8	10.4	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%

Middle 2 Bedroom Apartment – Climate Zone 66 Ballarat (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony West	5.1	248.6	231.2	17.4	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - Anti-glare foil with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.0	194.7	178.2	16.5	69.7	as above	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.5	166.8	151.7	15.1	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 21 Melbourne (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony North	5.0	148.4	98.2	50.1	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Aluminium framed clear single glazed Low-e: Sliding door (balcony) & kitchen window	19.98	28.7%
	6.1	111.4	69.8	41.6	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%
	6.5	97.8	59.6	38.2	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 21 Melbourne (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony East	5.0	148.0	121.2	26.8	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.1	109.3	87.6	21.6	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e	19.98	28.7%
	6.6	95.1	75.6	19.5	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e Thermally broken aluminium framed clear double glazed argon filled Low-e: kitchen / dining windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 21 Melbourne (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony South	5.1	146.0	95.7	50.3	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony) & kitchen / dining windows	19.98	28.7%
	6.1	110.6	66.4	44.2	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e Thermally broken aluminium framed clear double glazed argon filled Low-e: Dining windows	19.98	28.7%
	6.6	95.0	56.1	38.9	69.7	as above	as above	as above	Capral	Thermally broken aluminium framed clear double glazed argon filled Low-e Aluminium framed clear double glazed Low-e: Sliding door (balcony)	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 21 Melbourne (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony West	5.2	142.0	97.1	44.9	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.1	109.9	72.4	37.5	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.6	95.6	59.8	35.8	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony) & kitchen / dining windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 62 Moorabbin (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony North	5.0	164.3	129.1	35.2	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Aluminium framed clear single glazed Low-e: kitchen window	19.98	28.7%
	6.1	120.6	92.4	28.2	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony) & dining windows	19.98	28.7%
	6.6	104.3	77.3	27.1	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony)	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 62 Moorabbin (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony East	5.1	158.8	140.5	18.3	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.1	120.3	104.7	15.5	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony) & kitchen / dining windows	19.98	28.7%
	6.6	103.5	89.8	13.8	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e Thermally broken aluminium framed clear double glazed argon filled Low-e: Dining windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 62 Moorabbin (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony South	5.1	161.7	131.4	30.3	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.0	124.7	94.6	30.1	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony) & kitchen window	19.98	28.7%
	6.7	102.2	75.7	26.5	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e Thermally broken aluminium framed clear double glazed argon filled Low-e: Dining windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 62 Moorabbin (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony West	5.4	150.0	120.1	29.9	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.1	122.7	98.1	24.6	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.5	107.6	83.6	23.8	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony) & dining windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 66 Ballarat (North)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony North	5.1	250.4	214.9	35.5	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Aluminium framed clear single glazed Low-e: Dining windows	19.98	28.7%
	6.1	194.0	165.4	28.7	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony) & dining windows	19.98	28.7%
	6.5	167.4	140.1	27.3	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony) & kitchen window	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 66 Ballarat (East)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony East	5.1	249.8	229.4	20.4	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.0	194.8	177.7	17.1	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Aluminium framed clear double glazed Low-e: Sliding door (balcony) & kitchen / dining windows	19.98	28.7%
	6.6	163.3	149.1	14.2	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e Thermally broken aluminium framed clear double glazed argon filled Low-e: Dining & kitchen windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 66 Ballarat (South)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony South	5.1	251.3	206.6	44.7	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 20mm Green Foilboard with dual reflective airspace Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Sliding door (balcony)	19.98	28.7%
	6.0	195.0	150.7	44.3	69.7	as above	as above	as above	Capral	Aluminium framed clear single glazed Low-e	19.98	28.7%
	6.6	162.7	123.8	38.9	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed Low-e Thermally broken aluminium framed clear double glazed argon filled Low-e: Sliding door (balcony) & dining / kitchen windows	19.98	28.7%

Corner 2 Bedroom Apartment – Climate Zone 66 Ballarat (West)

Dwelling	Star Rating	Energy Demand(MJ/m2)			Area	Floors	Walls	Ceilings	Windows	Window Description	Glazing Area	Glazing / Floor Area
		Total	Heating	Cooling								
Balcony West	5.1	251.7	214.2	37.5	69.7	Concrete - Neighbouring No Insulation	Pre-cast concrete - 10mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	Concrete - Neighbouring No Insulation	Capral	Aluminium framed clear single glazed	19.98	28.7%
	6.1	193.4	163.2	30.1	69.7	as above	Pre-cast concrete - 20mm Green Foilboard with 28mm batten Apartment party and corridor walls - R 1.5 bulk insulation	as above	Capral	Aluminium framed clear single glazed Low-e Aluminium framed clear double glazed: Dining windows	19.98	28.7%
	6.7	161.2	132.2	29.0	69.7	as above	as above	as above	Capral	Aluminium framed clear double glazed	19.98	28.7%

Appendix D: Consultations

Stakeholder #1

1	Current role?	Director of medium-sized architectural practice
2	How many years' experience working in residential sector in Victoria?	8
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	None relevant
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	 • 5% • 5% TH • 85% • 5%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	 • No • n/a
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	Limited DtS experience.
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort?	

	• Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• Practice has worked on several Nightingale model apartment projects, all requiring minimum 7½ star NatHERS. Driver was affordable home ownership and low heating and cooling costs. • Have worked on a number of projects with Green Star benchmarking i.e. average 6½ star, minimum 5½ star NatHERS
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	• North-facing roofs generally reserved for solar PV due to better value and lower maintenance so solar hot water rarely installed. • Most homes will therefore have rainwater tanks
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	•
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Building surveyor generally defers to advice of ESD consultant (where this is one) following modelling assessments.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• No
14	Renovations: • What proportion of your residential renovation experience relates to houses?	

	• Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Response to climate change via shift towards fossil-fuel free developments and all-electric developments including cooking, hot-water generation and much cheaper solar PV. • Increasing energy prices
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Lingering lack of foresight and innovation towards all-electric designs. Fire pumps still forced to have diesel generator back-up as City Power still won't accept battery storage as back-up for electric pumps. • Traditional definition of thermal comfort parameters leads designers towards increased level of heating, ventilation & air-conditioning (HVAC) systems and associated operational costs, and can lead to disconnection from the environment.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• More emphasis on passive design solutions such as orientation, shading, material selection.
18	Do you know the NatHERS rating of the home you live in? How/why?	• 7-8 star (Nightingale 1.0 development).
19	Any other comments?	More regulations / incentives needed to reduce waste and close the waste-to-resource loop in residential design, particularly in the context of food-security.

Stakeholder #2

1	Current role?	Director of ESD consultancy
2	How many years' experience working in residential sector in Victoria?	10yrs
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	NSW 2 yrs, non-resi sector experience from Europe.
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 30% • 10% TH • 50% • 10%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• Lapsed formal NatHERS accreditation • No
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	• Limited
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Now much easier to procure high-performance windows • High-performance whole-house ventilation systems (MVHR systems) weren't readily available in Australia 5 years ago. Only a couple of models available – now around 10, and around 20% cheaper than 5yrs ago. Often installed as a measure that also minimises risk of internal condensation.
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates?	• Generally slow, small improvements across the board.

	• Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• Delivering beyond minimum compliance is our target market. • Apartments are easier to attain/exceed NatHERS compliance than houses. But future stringency increases should remain level to continue to reward inherently more sustainable high-density typology.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	• All-electric homes are increasingly attractive contributing to prioritisation of solar PV over solar hot water. •
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	• Often caught at contract stage and rectified by last-minute (more expensive) fixes.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Mostly positive experiences through repeated partnering with RBS and associated growth in understanding and awareness . • Other surveyors often take tick-box approach to energy compliance – don't attempt to engage with Section J compliance or review reports.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• Air-tightness testing and thermography commonly done, particularly due to Passivhouse targeting projects.
14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).*	• All reno experience relates to houses, not apartments or townhouses • Guidance needed with regard to partial-compliance re potential definitions of 'reasonable' and 'cost-effective' etc.

	o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Usually driven by client motivation, particularly those who have lived overseas, or want enhanced health & well-being.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Requirement within Plumbing Code for every house to have a gas connection is well-intended but now outdated in the context of ever-widening difference between gas and elec prices, and availability of cost-effective PV + batteries + induction cooktops etc.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Promoting awareness and education e.g. via Mandatory Disclosure of energy ratings (e.g. ACT). • Mandatory air-tightness standards with approvriate ventilation to compensate e.g. MVHR and/or trickle vents. •
18	Do you know the NatHERS rating of the home you live in? How/why?	• 0.2 star self-assessed prior to upgrading in order to measure improvement.
19	Any other comments?	

Stakeholder #3

1	Current role?	Director of architecture practice
2	How many years' experience working in residential sector in Victoria?	21 years
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	-
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 40$ • 15% TH • 5% • 40%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• No – use regular ESD consultant
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	-
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Double-glazing previously was a premium product. Used to cost double that of single-glazing, now 15% premium. • Typical insulation depths have increased. • Costs of LED lighting, solar PV have plummeted over the last decade. • Cost of building in VIC has gone up due to demand from population growth so impact of increased energy-efficiency measures has been dwarfed.
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates?	• Initial transition from 5-star to 6-star focused on mere compliance while industry adapted to new rating tool. • Learning curve for designers typically completed within 2-3 years. • Switch to 3D design tools over the last decade has improved awareness of solar design principles – e.g. shading and beneficial sunlight admission in winter.

	• Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• Common due to 'We educate' approach. • Emphasise 'Design to Perform' rather than 'Design to Comply' • Apartment block has achieved over 8 star NatHERS. Apartments are much easier to design above statutory compliance. • Getting from 6-star-7-star is now more affordable than getting from 5-star-6-star due to relative increase in base-cost of house over the last decade. •
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	• Many dislike dirty water in WCs from rainwater tanks.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	-
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Tend to blindly stamp rather than review energy reports. • Don't inspect sites so limited motivation for builders to comply • More recent planning permit conditions from inner metro councils require confirmation by author of sustainability management plan that built in accordance with SMP.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• No • Yes, open plan living spaces and stairwells in houses frequently result in overheated upstairs vs underheated downstairs. Only downstairs heating used (if system is zoned).
14	Renovations: • What proportion of your residential renovation experience relates to houses?	• All reno experience is for houses, not others

	• Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	• Overcompliance achieved in house extension where 3.5-star partial required but 4.5-star achieved.
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Cost of gas and electricity • Improved architect awareness • Energy regulatory changes • Range of compliance measures required in council ESD policies.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Clients believing that solar PV is only worthwhile if you also have batteries. • Water conservation and WSUD policies given too much weight by council policies • Locally-made thermally-broken window frames still significantly poorer energy performance than European norms.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	More user-friendly home user guides (HUGs) needed – education & awareness lacking.
18	Do you know the NatHERS rating of the home you live in? How/why?	• 6-star - self-built
19	Any other comments?	• Roof-garden opportunities being denied due to councils considering as an additional storey. • Achieving site permeability ratio on urban blocks harder as blocks get smaller and houses get bigger (planning policy driven). Should not be as high a priority as energy-efficiency.

Stakeholder #4

1	Current role?	Senior façade engineering consultant
2	How many years' experience working in residential sector in Victoria?	8 yrs
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	-
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	 • 1% • 2% • 95% • 1%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	 • Experienced users in-house, but non-accredited • Experienced users in-house, but non-accredited
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	 • No • No
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	 • Façade systems are directly procured via head-contractors, not the façade contractor. • Australian supply-chain has limited product scope and has demonstrated limited adaption rates to supply commercial-scale apartment developments. • Some local fabricators supply only via joint-ventures with overseas manufacturers. •
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)?	 • Construction industry tend not to take energy performance seriously. Poor awareness of issues and siloed mentality to solutions. • On large projects most consultants become novated to a D&C contractor after contract stage therefore suffer split-incentives between enforcing good-practice design and satisfying contractor priorities.

	• Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• Some manufacturers have tried copying European high-performance façade systems but local site-based skill sets for correct installation are lacking resulting in system failures.
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• 2 large apartment projects requiring average 8 star, minimum 7-star NatHERS (partly Green Star driven) • Large office building designed to Passivhaus standards (owner-occupier client). • Incidental overcompliance not an issue.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	n/a
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	• Seen as RBS responsibility.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Self-regulating. Inconsistencies, accountability limited?
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• Company follows QA procedures re window-performance verification (weethering etc., not energy-related)
14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).*	n/a

	o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	Increased stringencies in regulation and guidance.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	National WERS database no longer fit-for-purpose due to evolution of range of high-performing IGU and frame combinations, particularly from overseas. 'Ditch not fix..!' Standard window dimension assumption much less relevant due to custom sizes becoming the norm rather than the exception.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Mandatory minimum performance for thermal bridging elements required within NCC. e.g. fixing of shading fins and balconies through façade elements.
18	Do you know the NatHERS rating of the home you live in? How/why?	No
19	Any other comments?	Too many architects prioritising cosmetic appearance of highly-glazed facades over glazing performance e.g. high VLT (visual light transmission) for daylight amenity.

Stakeholder #5

1	Current role?	Director – House Builder & NatHERS assessor. Target market is owner-occupiers wanting low-energy homes.
2	How many years' experience working in residential sector in Victoria?	Since 2001.
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	No.
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 50% • 5% TH • 0% • 45% extensions/renovations
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• NatHERS – Accurate & FirstRate • No
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	Always NatHERS.
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Aluminium double-glazing frames initially attracted premium pricing as there were less extrusion dies for these. • Timber and timber/aluminium hybrid window frames have improved greatly, and now represent the majority of our projects. • Double-glazing inevitable to a greater or less extent. Clear low-e glass common. • uPVC doors now have much better sealing characteristics than timber. • Sprayed expanding foam for closing gaps and penetrations, used to be only available from specialist distributors, now easy to obtain. • Same for Sisalation (sarking) tape. • LED lighting now affordable, has become standard. • Fashion is shifting from downlights (which create multiple ceiling penetrations) to flush/suspended fittings. • Achieving air-tightness now much easier due to above factors, and affordable diagnostic gadgets e.g. thermographic smartphone attachments. • Biggest cost impact was VBA requirement for rainwater tank/solar hot water.

8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• Typically increased house wall insulation from R2.5 to R3.5, and house ceiling insulation from R2.4 to R4. This added only $500 to build cost. • Bulkfill insulation products still dominate housing sector. High-performance foam generally still not cost-effective for most houses types. • Specialist trades took longer to adapt to changes – certification training has assisted in raising awareness of energy agenda, and should cover importance of sealing penetrations and caulking.
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• To consumers 6-star already sounds like the best-possible, as it is with many domestic appliance energy ratings, NABERS ratings, hotels etc. • Most of our houses achieve 8½ to 9 stars, as this is the sweet-spot for our target market of motivated owner-occupiers. • Green Star Materials category has made finding certified eco-products easier by incentivising eco-labelling in Australia.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	This requirement represents a bigger cost impost than the 1 star NatHERS upgrade. Always install both for my clients.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	Used to install additional insulation to provide a safety margin during construction process to offset potential unsealed penetrations or gaps but this caused difficulties with a building surveyor since provision was slightly beyond that nominated in the NatHERS rating so no longer do this..!
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	Most never come to inspect insulation & glazing provision on-site – at best only perform a paper check. This should be mandatory. Surveyors generally only focussed on life-safety regulations.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received post-occupancy feedback from occupants and/or construction team?	Have own thermographic camera to ensure trades have been diligent. Offer consumers blower-door testing option (approx. $600). Reliably achieving air-tight construction has been a very quick transition process from previous habits.

14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences: o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	• 100% housing • Insulating existing shell is the hardest and therefore encounters most resistance. Insulating under floor on stumped houses too difficult if void less than 400mm high. • Blow-in expanding foam products now more widely available. • Surveyor typically takes difficulty advice from the builder who controls the budgeting so may inflate price estimates of undesired initiatives.
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Drought and climate change awareness. • BCA Section J. • Construction sector understanding improved via Masterbuilders and HIA running Green Living Program training programs. • Energy and solar PV costs. • BDAV 10 Star Challenge and Passivhouse movement. • Increasing viability of all-electric new homes. • BZE and ATA resources.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Site inspections, particularly of insulation compliance. • Entrance doors insulation properties not regulated or modelled within NatHERS. • Heritage overlays over aggressive implementation e.g. solar PV disliked.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• On-site compliance – e.g. all housebuilders to purchase IR cameras e.g. as low-cost smartphone attachments. • Regulation e.g. regulate air-tightness standards – cost of air-tightness (blower-door) testing now typically $600 per house. Set the bar high but show leniency for transition period to allow industry to adapt. • Mandatory disclosure of energy performance.
18	Do you know the NatHERS rating of the home you live in? How/why?	Yes, 9 stars (self-built).
19	Any other comments?	• Current NatHERS 6-star standard very easy to achieve. Better for Victoria to lead than to follow e.g. South Australia renewables experience and ACT mandatory disclosure.

Stakeholder #6

1	Current role?	Managing Director of airtightness-testing and Residential Scorecard Assessment firm.
2	How many years' experience working in residential sector in Victoria?	3½ years
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	-
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 60% • 10% TH • 15% • 15%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	-
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	n/a
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Availability, quality and cost of instrumentation for on-site validation of performance has improved significantly.
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort?	• Improvement in construction awareness and skills lagging behind improvements seen in the design sector.

	• Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• Aspirational standards most common with owner-builders and 'greenies' (more prevalent demographic within inner suburbs).
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	n/a
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	• Our airtightness inspection and testing work often exposes missing dampers for exhaust ducts and fans, rangehood exhausts into roofspace. • Following trades typically don't report or re-instate displaced insulation etc. Bulkheads and dropped-ceilings frequently not insulated in space above – out-of-sight, out-of-mind issue.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Surveyors are not on-site when discrepancies would be visible. • Surveyors don't carry any tools to site that would assist in discovering non-compliances re thermal envelope etc. Requires education / awareness / incentive to correct.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• That's our principal role •

14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	• Mostly houses. • Many renovators will go to extraordinary lengths to avoid additional expenditure triggered by compliance requirements. Builders will often talk clients out of increased complexity due to seeking compliance. They prefer to keep things simple – fear of the relatively unknown…
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Regulations are the number one driver of change. • Ownership – more homes built as investment properties with low motivation to create energy-efficient outcomes.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Uneven playing field re compliance pathways • Low general awareness / education around key issues •
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Install insulation right – accredited installers • Install door seals correctly – frequently on the wrong side. • Specify insulated doors – no recognition within NatHERS rating.
18	Do you know the NatHERS rating of the home you live in? How/why?	Home construction preceded NatHERS.
19	Any other comments?	• Better building envelopes should result in smaller and cheaper heating and cooling system installation, but designers have to trust it will be built well to downsize systems appropriately. • Average 'man-in-the-street' even amongst well-educated have low awareness. e.g. architects unaware of consequences of unimpeded airflow causing heat to rise from open-plan ground floor to 1st storey. Too cold downstairs, too hot upstairs. Physics 101. • Designers more concerned about making architectural statements than creating comfortable, efficient homes.

Stakeholder #7

1	Current role?	Managing Director – Insulation manufacturer, Victoria
2	How many years' experience working in residential sector in Victoria?	20 years
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	National product distribution
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	 • 10% • 10% • 70% • 10%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	 • Yes • n/a
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	• Both alternative pathways have resulted in under-performing outcomes. DTS particularly prevalent with Tier 3 & 4 builders, and in QLD.
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Impacts were less than might have been anticipated due to increased use of alternative compliance pathways above. • Insulation generally cheapest to procure in VIC due to demand and central location. • Inferior imported insulation products problematic – distributed via pop-up trading entities who subsequently dissolve. Lack of policing and regulations is harmful to customers and industry. Imported polyester flexible insulated duct for domestic ducted gas heating is frequently non-compliant. •
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold?	

	• Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• Designs have evolved well. • Cost of insulation has dropped, particularly via reduced profit margins. • There are few supply-side constraints. Just waiting for demand. • Cost per R-value has never been cheaper. • Underfloor insulation much more common. • Consumer awareness still generally poor.
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	n/a
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	n/a
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	Non-compliance affects demand and therefore supply chain.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	Empathise re challenges faced by surveyors. Who actually sees the slab being poured?
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	n/a
14	Renovations:	

	• What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	n/a
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	Mandatory disclosure of energy ratings e.g. in ACT – a low-cost enabler of impact.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Date/Time and GPS location stamped photo evidence of hidden insulation important to mandate. • A home-construction electronic passport held by local council should be possible e.g. using blockchain / BIM type databases. • ASBEC-type structured pathway towards Net Zero standards essential for industry planning. Supply chain can ramp up to offer more and better products. • Demand incentives to provide modular systems – fabricated off-site.
18	Do you know the NatHERS rating of the home you live in? How/why?	No, but we know the energy rating of our factory.
19	Any other comments?	Greater stringency re NatHERS ratings supported. An opportunity to demonstrate leadership, as previously. Victoria's extreme hot and cold weather climate particularly justifies a leadership position.

Stakeholder #8

1	Current role?	General manager – fenestration certification.
2	How many years' experience working in residential sector in Victoria?	20
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	-
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	N/A
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	AFRC Simulator accreditation.
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	N/A
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Local residential aluminium window frame manufacturers started extruding double—glazed profiles in 2008 in response to shifting regulatory environment, and a shift towards custom window sizing in the housing market, driven by more contemporary design aesthetic. • Residential window performance has lagged behind commercial window performance. • Insulated glazing units (IGUs) using locally-distributed glass can now be triple the price of imported IGUs. Local pricing is often opportunistic, and driven by sector busyness – currently very high. • Low-e coatings are still not produced by Australia's sole glass manufacturer of float glass. Investment in new production line not considered viable in current market. • For the housing market thermally-broken (TB) framed windows were less than 1% of the market around 2014.

8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• Glazing extents tend to reduce each time energy stringency is increased, as this is cheaper in the short-term than procuring higher-performance windows. • By contrast a trend in house design over recent years has been to spend dramatically more on feature front-doors and stone benchtops. i.e. energy-efficiency still undervalued/disconnected despite sharply-rising energy prices.
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	N/A
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	N/A
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	N/A
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	N/A
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• Thermography started being used in 2012 by premium housebuilders as a way to demonstrate/differentiate quality of build. • Double-glazing seen as quiet and comfortable

14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences: o Process? O Effort and cost vs. value? O Potential improvements to compliance standards/processes?	• Personal experience – little point in upgrading to high-performance windows in house if you can't insulate the ground floor (floor void on stumped house not sufficient to install insulation below.
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Premium performance glazing products now widely available at affordable pricing.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	Urban myths: • 'Sydney and Brisbane don't need high-performance windows due to milder climates.' • uPVC windows not suitable for Australia. •
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Mandatory disclosure of energy ratings e.g. ACT experience • Marketing – emphasise increased acoustic performance and thermal comfort close to large windows (usable space) - sells better than energy-efficiency/sustainability messaging. • Use max/min temperature predictions of NatHERS free-running mode modelling to promote comfort. • Publish condensation ratings for high-performance windows – i.e. health & well-being factor.
18	Do you know the NatHERS rating of the home you live in? How/why?	No
19	Any other comments?	• Upcoming updates to NCC Section J re energy-efficiency are a significant 'scare factor' for local industry resulting in real current (2018) impacts in the manufacturing sector - gearing up for shifting product demands. • In the new Section J and VBA Practice Notes etc. reference U-values for walls, rather than R-values, as is the norm beyond Australia. This helps establish awareness of just how poor the performance of IGUs and frames are relative to insulated walls etc. e.g. a typical wall may be R2.5, or U=0.4, relative to a typical window of U=4.0 i.e. 10 times worse than the wall.

Stakeholder #9

1	Current role?	CEO
2	How many years' experience working in residential sector in Victoria?	6 years personally, 34 years organisationally.
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	Yes.
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations?	No data.
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	NatHERS – all members.
6	Impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Industry product availability/cost/quality, Victorian/Australian market transformation? • Design effort? • Construction effort? • Comfort (thermal & acoustic)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Supply Chain? o Construction/fabrication teams? • Developer and consumer awareness, changing market expectations?	○ Impacts embedded in training units for members. ○ Implementation delayed by over a year in many cases due to timing of planning lodgements, and 'substantially-designed' clause within Section 10 of the Building Act. ○ Most NatHERS assessors took a 'roll with it'. Older assessors adapted more slowly. ○ Volume house builders adapted better than smaller house builders due to better resources to model templated homes. ○ BDAV did not support regulations potentially requiring their assessors to carry out compliance site-inspections on their projects. This responsibility remains with the building surveyor. ○ Common perception is that building surveyors are mostly focussed on compliance issues relating to life-safety and neglect NCC Section J policing. ○
7	Experiences of alternative NCC Section J compliance pathways in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	○ DtS still lingering despite generating poor solutions. ○ V2.6.2.2 pathway can results in compliance for homes that would otherwise rate 3½-4 star NatHERS. ○ Data-capture re compliance pathways can be inconsistent resulting in difficulties in marrying data-sets.

8	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance?	○ BDAV 10-star challenge competition launched when 6-star standard enforced in Victoria. 1st 10 star home completed in 2017. ○ Townhouses can be Class 1a or Class 2, resulting in differing NatHERS compliance pathways, dictated by unrelated factors e.g. common basement parking area.
9	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	The cheapest (capital cost) option wins.
10	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	○ BDAV have been conducting monthly-auditing of accredited assessors since 2009. ○ Compliance rates are understood to have increased from 35% to 65% between 2016 and 2017 due to improved online training and guidance, and recent shedding of members with intermittent usage due to new accreditation standards.
11	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	○ Inconsistent approach and interpretations ○ Section J compliance not the focus of their attention since non life-safety.
12	Renovations: • Do you have any residential renovation energy performance experience outside of houses? • Key observations from your experiences: o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	○ Particularly beholden to surveyors' approach. ○ Inconsistency leads to uneven playing field for owners. ○ Guidance needed re definition of 'reasonable' measures e.g. ○ Some householders gain the occupancy permit first then retrofit the non-compliant elements the next day.
13	Most significant drivers of change / impacts of change over last decade with respect to sustainable residential design in Victoria?	Legislation!
14	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	○ Non-accredited assessors ○ Inconsistencies re compliance through procurement, construction and permitting. ○ Lingering 'hippy' perceptions re green agenda. Energy-efficient design better promoted via benefits e.g. comfort and costs etc.

15	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	○ Regulate! ○ Increased stringency with adequate notice periods and allow supply chain (manufacturers and design consultants) to adapt in a competitive market. ○ Minimum elemental standards for windows and walls – e.g. prohibit single-glazing so that manufacturers tool-up for double-glazing and prices drop. 'If you build it, they will come'.
16	Do you know the NatHERS rating of the home you live in? How/why?	Yes
17	Any other comments?	DELWP could disallow unaccredited assessors via VBA e.g. mandatory registration and certification declaration e.g. ACT.

Stakeholder #10

1	Current role?	Principal – residential energy consultancy
2	How many years' experience working in residential sector in Victoria?	10 yrs
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	-
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	Residential sectors follow differing cyclic peaks & troughs but on average: • 65% • 10% • 5% • 20%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• NatHERS accreditation via both BDAV & ABSA
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	• DtS not used in over 5 years. The NCC glazing calculator has glitches that can easily be fixed e.g. shading and incorporating input parameter constraints. • No. Can be done in BERS Pro but results can be controversial.
7	Supply chain impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Local availability of exemplar low-e IGU products e.g. Viridian Lightbridge. • The only Australian glass manufacturer (Viridian) now doesn't bother with the option to fill IGU cavity with air. More cost-effective to just give everyone Argon (better performance) than to chop and change production. • Composite timber-aluminium frames are now locally manufactured giving high-performance without timber maintenance concerns. • Local production of high-performance rigid insulation products have made high performance walls possible at acceptable wall thicknesses (loss of floor area).
8	Other impacts of Victoria's unilateral change from 5-star to 6-star NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates?	• Majority of industry appears to have absorbed very little since the beginning of the decade . Most still not familiar with basic sustainable design principles and basic glazing performance parameters such as SHGC, VLT etc. • People relate to comfort parameters such as temperature better than to energy metrics.

	• Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• Design process - collaboration becoming more common though still not the norm e.g. early involvement of ESD input. • • Success breeds success. Design teams re-collaborating on subsequent projects promotes knowledge growth.
9	Experience designing/delivering beyond 6-star NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• Have been involved with 9 star NatHERS homes built in Victoria and 10 star design competitions. • Incidental overcompliance rare. Design/rating safety margins included to allow for typical attrition through design-build process. Occasionally little attrition occurs resulting in small overcompliance.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	• No involvement. Rainwater tanks are common choices for housing.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	• VBA Practice Note 55 is long overdue for a thorough update. • Have seen NatHERS certificates with 'non-accredited assessor' warning note edited out!
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Surveyors are wildly inconsistent in application of compliance.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• Typically no direct involvement • Have tested for presence of low-e coating on glazing using colour shift between multiple reflections of lighter flame / smartphone torch. • Own thermography camera attachment for smartphone.
14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (25%/50% rule).* o Process?	• Experience of surveyor unilaterally downgrading achievable energy performance requirements. More guidance needed re 'reasonable' measures.

	o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Regulatory change has stimulated improved design collaboration habits and better availability and affordability of high-performance insulation and glazing.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• 'Australian window industry is broken'. WERS database is an outdated concept no longer relevant due to range of glass/frame permutations now available and relevant.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• More intelligent choice of roof and wall colours improves energy performance for free, though hard to get reliable manufacturer data on thermal absorptances.
18	Do you know the NatHERS rating of the home you live in? How/why?	• No - 120 years old.
19	Any other comments?	-

Stakeholder #11

1	Current role?	Aluminium window manufacturer – Architectural specifier
2	How many years' experience working in residential sector in Victoria?	5 yrs, (Victoria & Tasmania)
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	16 years in the UK
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 70% houses & Townhouses • 25% apartments • 5% renovations
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• 1 NatHERS assessor
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	Software such as the NCC J2 calculator could easily be amended to disallow impossible inputs e.g. window SHGC >0.87, U-values >7, and red-flag improbable inputs e.g. SHGC < 0.1 etc.
7	Supply chain impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	Since the NatHERS regulation change, thermally-broken frames comprise 10-15% of the market. Window profit margins for non-standard products i.e. high-performing frames and IGUs can be very high, particularly when the industry is busy and fabricators don't need the work. In the past the rule of thumb was than any developments over 15 floors would get their facades from Asia. Industry partnerships have now lowered that threshold, but you have to pay 100% upfront and wait 8-10 weeks for delivery. There has been more recent movement back towards more local product due to less advantageous exchange rates, combined with occasional damaging experiences with incorrect or defective shipments.
8	Other impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold?	

	• Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	House-building sector has had high investor-driven proportion. At current stringency, NatHERS compliance can often be achieved more cost-effectively by boosting wall and roof insulation levels than by improving window performance. Thermal comfort and acoustic comfort more closely linked to performance of weakest link in envelope i.e. the glazing. Comfort therefore compromised in investor home sector. Tasmanian market similarly influenced due to higher sensitivity to capital costs than Victoria -probably linked to lower wages and lower land prices.
9	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	N/A
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	N/A
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	N/A
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	N/A
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	N/A
14	Renovations:	

	• What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	N/A
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	Regulatory standards first and foremost - provides the trigger to raise awareness and enhance standard practice. Architects are second biggest factor. Most still design and specify based on appearance alone. Still generally very poor understanding of difference between key performance parameters e.g. U-value vs Solar Heat Gain Coefficient (SHGC), and how these can be enhanced.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	Weak regulations and regulatory structures: 'You can't polish a turd, but you can roll it in glitter.' Misconceptions that applying film to glass on new-builds is an effective option to improve performance.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	Regulations that would eliminate market for single-glazing and standard aluminium frames.
18	Do you know the NatHERS rating of the home you live in? How/why?	No, but have a 4.2 star Victorian Residential Efficiency Scorecard Certificate for 1920's renovated home. Very positive experience.
19	Any other comments?	

Stakeholder #12

1	Current role?	MD of uPVC window profile manufacturer and window fabricator
2	How many years' experience working in residential sector in Victoria?	26 years based in NSW (some projects in Victoria)
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	All Australian states except NT, overseas experience re kit-homes
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 50% new houses and townhouses • 50% renovations, including occasional apartment building
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	N/A.
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	N/A
7	Supply chain impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Sector previously tainted by lack of local standards and glut of low-quality fabricator start-ups, using PVC types unsuitable for Australian UV levels. • European-style hardware locking points used by better fabricators to give best sealing – also improves acoustic performance. • Local costs still high compared to overseas uPVC manfacture, though are the most cost-effective frame choice ($/MJ) e.g. thermally-broken aluminium frames cost up to 30% more for worse performance. ○ Labour costs very high. Scale and market certainty required to justify investment in automation ○ Australian glass is expensive, though set to decrease in price with new state-of-art facilities coming online ○ Local PVC costs high though environmental credentials second-to-none in Australia through work of Vinyl Council & GBCA. ○ Local aluminium hardware costs high due to energy costs for smelters.

8	Other impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• A decade ago the market for uPVC windows was largely-driven by ex-European customers retrofitting Australian homes to attain thermal and acoustic comfort expectations. • Early take-up also driven by the ACT market (cold-climate + mandatory rating disclosure). • Alpine and Tasmania regions are strong markets - colder climates with strong winds requiring enhanced sealing. • More recent surge in interest and demand driven by improved awareness. Has caused overall pricing to rise due to higher opportunistic installation costs associated with demand outstripping availability of experienced installers.
9	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	N/A.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	N/A.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	N/A.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	N/A.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	N/A.

14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	• >95% of current market is renovations. • N/A
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Regulations drive change by creating certainty and level playing field. • Most builders fear change, resulting in risk-pricing for unfamiliar technologies. • Australian architects can be biggest obstacle in new-build take-up due to cosmetic preferences.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Awareness - low market expectations of customers not previously exposed to European high thermal and acoustic performance. • Misconception that high-performance glazing only useful in cold-climates. Also vital in hot weather but users need to learn to keep windows closed on hot days..
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Improved energy and comfort standards – regulate against worst product types e.g. use of single-glazed, uncoated glass to transform market. e.g. Scandinavia experience.
18	Do you know the NatHERS rating of the home you live in? How/why?	No. Existing home. Also less relevant in NSW due to BASIX.
19	Any other comments?	

Stakeholder #13

1	Current role?	Registered Architect, Practice Leader, BDAV committee, Passivehouse Certified Consultant
2	How many years' experience working in residential sector in Victoria?	11
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	Worked in Germany and Ireland
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 33% • TH 33% • 1% • 33%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• 2 x NatHERS •
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	• DTS Not used • Verification modelling should be banned (too lenient and easily abused)
7	Supply chain impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Govevernment interventions create biggest demand for products, and impacts • Regulations/policies initiate discussion and education • Costs follow competition, which follows demand • Biggest change has been switch from mostly single-glazed to mostly double-glazed windows • Local manufacturers of Passivehouse performance windows e.g. Parhammer, Binq currently seeing 6-9 month lead times due to demand outstripping capacity
8	Other impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates?	• Compliance rates slowly improving, but still very far off acceptable. Experience of energy raters misusing total R-value as added R-value. • Industry adaptation period probably 2-3 years learning curve • Awareness improving, better education filtering through

	• Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	• Builders are the main laggards – split into 2 groups, small minority who have embraced it and majority who don't get it.
9	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	• Have designed three 10 star homes but none built (to that level). • NatHERS tool not very robust beyond 8 stars – can distort effective design interventions, unlike Passivehouse PHPP software, which is well-proven for delivering outcomes consistent with the tool. • Have 2 Passivehouse designs currently being built. Autralia is 20 years behind Germany. • Council ESD policy requirements can be an effective lever to betterment • Apartments gain higher NatHERS ratings easier, but stringency for all typologies should be increased.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	• Our clients usually accept the architect's recommendation – typically to install rainwater tanks and solar PV in lieu of solar hot water panels, in conjunction with heat-pump hot-water, and increasingly all-electric homes. • Solar hot water considered out-dated
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	• Windows and insulation often mis-installed and/or below spec. • Underfloor heating with slab installation omitted on-site – picked up by time-lapse camera installed on-site as part of service.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• RBS rely on others as experts re Section J. Mostly selected and appointed by the architect so have only had difficulties with externally-appointed surveyor.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• Have own thermography camera • Window performance verified by WERS stickers, where rated • Lighter-flame used to verify low-e coating presence on glass •
14	Renovations: • What proportion of your residential renovation experience relates to houses?	• 99% of reno experience is houses

	• Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	• Can be genuinely hard to upgrade existing fabric. Incorporating double-glazing with high-performance frames often insufficient.
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Regulation • Education and awareness – some real estate agents improving slowly
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• On-site compliance certification should be mandatory. • Very had when architect does not get a contract administration role. Practice manages to achieve around 70% success in being commissioned for this role (typically 25-30% premium on architectural design fee). • Termite protection requirements within the Australian Standard requiring 100mm exposed concrete slab edges conflict with need for slab-edge insulation.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Site verification via time-lapse cameras, thermography etc.. • Ban verification modelling (Section J V2.6.2.2) • Ban downlights (increases roof penetrations and subsequent insulation and sealing deficits). • Mandate thermal-bridging constraints
18	Do you know the NatHERS rating of the home you live in? How/why?	Currently living in camper van whilst building a Passivehouse home
19	Any other comments?	• Victorian Residential Energy Scorecard ratings already being abused via estate agents advertising 10 star houses. Too easily confused with NatHERS ratings. Should avoid star rating nomenclature to avoid overlaps. Stars already completely over-used in Australian energy rating systems e.g. Green Star, NABERS, NatHERS, WERS, domestic appliance ratings etc. Scale is confusing - is 10 stars the best, or 6-stars..? (e.g. Green Star and NABERS and certain appliances) • Window performance metrics e.g. U-values. Australia follows NFRC (American) calculation rather than ISO standards as used in Europe e.g. Passivehouse. Means imported products face double the certification costs. • Beware looming issue of surface and intersitial condensation, mould etc. • Wood-fibre insulation boards have significant merits in terms of breathability and thermal and hygroscopic mass (decrement factor).

Stakeholder #14

1	Current role?	BDM of Victorian glass manufacturer
2	How many years' experience working in residential sector in Victoria?	15
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	25 yrs in the UK with international glass manufacturer
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	N/A
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	N/A
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	N/A
7	Supply chain impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• For last 5 years or so as a manufacturer we only fill IGU cavity with superior argon gas. Cost-difference does not justify offering air-fill option. • Double-glazing now standard product over last 2-3 years, credited to improving access and cost. • Viridian's Lightbridge soft low-e IGU product was game-changer in terms of performance and cost so instrumental re stimulating local competition. • Only hard low-e coat (pyrolytic) for single-glazing made in Australia. • Soft low-e glasses still mostly come from Europe/America due to importance of value over cost i.e. quality and surety of performance. • High-performance PVC window sector steadily growing, though still minor. Aluminium still dominates. • World-class glass facility recently built in Geelong. Ex-autoglass facility repurposed for flat glass with Victorian government grant assistance. Will transform cost and availability of IGUs (double glazing using local and imported glass products). Investment needed to manufacture glass with soft low-e coating still too high relative to current local demand levels.

8	Other impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	N/A.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	N/A.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	N/A.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	N/A.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	N/A.

14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	N/A.
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	Availability of better glass and frame products has stimulated enhanced local competition. Awareness has improved and there is increased brand-recognition for high-performance products. Radio advertising of PVC window replacement and air-conditioner/heater replacement now becoming more prevalent.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	In refurbishment-driven markets such as Europe the consumer has more influence on window performance. In new-build driven markets such as Australia the house-builder has the predominant influence on window selection, and therefore not driven by energy performance or comfort considerations. Established industry lobby groups have disproportionate influence. New industry pressure groups needed.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	Minimum elemental performance regulations needed. Non-prescriptive elemental code requirements provide too many opportunities for performance trade-offs against wall and roof performance allowing poor glazing products to retain a place in the local market. In other countries where minimum glass/frame performance has been introduced it has triggered 'over-night' transformation in industry capabilities. 'Legislative pull-through' is key.
18	Do you know the NatHERS rating of the home you live in? How/why?	No. Current house came with single-glazed low-e glass.
19	Any other comments?	Energy debate in Australia driven by politics of supply (power generation and infrastructure) considerations. Not enough emphasis on demand regulation through better building fabric and more efficient appliances etc.

Stakeholder #15

1	Current role?	Director – Registered Building Surveyor firm
2	How many years' experience working in residential sector in Victoria?	30
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	18 months in NSW
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 5% • 10% TH • 80% • 5%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• No, but used to do NatHERS assessments pre 2007. Common role for building surveyor until introduction of 5-star standard and accredited energy raters.
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	• Still see DtS assessments for housing though disappeared for a while. • Have only encountered two V2.6.2.2 assessments in 10 years.
7	Supply chain impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	• Windows are the biggest issue as the weakest link and have changed the most – no glazing performance requirements pre-2008, only minimum wall and ceiling insulation.
8	Other impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality?	The 5* to 6* change was hardest for houses (NCC Class 1). Apartments found it harder to get from 3* to 5* previously.

	• Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	Government projects led Green Star adoption but rarely certify their ratings e.g. ABCB building.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	Many houses install both – rainwater tanks popular after drought, and solar hot water very marketable since gas price rises.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	Builders often de-spec the design to achieve cost savings.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Will check fire walls for penetrations (life-safety consideration, not air-tightness for energy-efficiency). • Discretionary dispensations will become less common as now has to be fully documented on the Building Permit (since 2nd June 2018). • Non-accredited NatHERS assessors?
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	• No. • Post-occupancy complaints due to over-heating related to expansive west-facing glazing.
14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).*	• All my reno experience relates to housing • More guidance needed. • No requirement for builder in charge of site to be an RBP problematic.

	o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	• Cost and availability of LED lighting, solar PV stimulated by associated government incentives. Less sub-standard products flooding market due to rise of minimum standards (driven by funding criteria). e.g. when majority of lighting products on Bunnings shelves are LED rather than tungsten it speaks to domestic consumers. • Cost and availability of better windows e.g. low-e double-glazing, and window frames e.g. thermally-broken.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Compliance. • Consumer awareness • Tradie awareness
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• VBA to promote awareness to builders and particularly sub-contractors to insist on receiving stamped drawings and energy rating reports. This used to be the norm prior to early '90s when code compliance was administered through councils, prior to privatisation of compliance certification. • Simple messaging needed re above, similar to insisting on having an RBP and site induction cards. • Mandatory disclosure of energy performance of dwellings e.g. NatHERS design ratings, as-built scorecard ratings (e.g. ACT), or recent energy bills.
18	Do you know the NatHERS rating of the home you live in? How/why?	Yes – 4* due to extensive renovations some time ago.
19	Any other comments?	

Stakeholder #16

1	Current role?	Energy consultant and analyst
2	How many years' experience working in residential sector in Victoria?	30
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	International work via ACEEE/ECEEE
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations?	Mixed
5	Do you, or anyone else in your organisation hold NatHERS Assessor accreditation?	Yes
6	Impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Industry product availability/cost/quality, Victorian/Australian market transformation? • Design effort? • Construction effort? • Comfort (thermal & acoustic)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Supply Chain? o Construction/fabrication teams? • Developer and consumer awareness, changing market expectations?	• Little change in moving to 6-star – could have gone to 7 or 8 • Houses last 50+ years, need to think about the longer term • Apply a low discount rate because of this • Both heat pumps and solar hot water heaters are generally of very low quality – questionable whether they comply with Australian Standards. Also for gas storage units; whereas instantaneous gas tends to outperform AS expectations in the field. • Sustainability Victoria has undertaken a hot water retrofit trial and should have data; similar work done in South Australia by Stephen Berry. • Sceptical of reports of 'hotboxes', but agreed that separate heating and cooling caps should have been applied. Also, noted that the impact of under-estimated cooling loads is all about the few very hot days per year, where peak demands have been rising strongly. NatHERS heating estimates are about right, but cooling not so. • Significant resistance to solar passive design in the development community and possibly consumers as well.
7	Experiences of alternative NCC Section J compliance pathways in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	
8	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how?	

	• Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance?	
9	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	
10	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	
11	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	
12	Renovations: • Do you have any residential renovation energy performance experience outside of houses? • Key observations from your experiences: o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
13	Most significant drivers of change / impacts of change over last decade with respect to sustainable residential design in Victoria?	
14	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	
15	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	
16	Do you know the NatHERS rating of the home you live in? How/why?	
17	Any other comments?	

Stakeholder #17

1	Current role?	Energy analyst and consultant
2	How many years' experience working in residential sector in Victoria?	30
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	Engagement internationally via IEA and ACEEE/ECEEE
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations?	Analyst working across all sectors.
5	Do you, or anyone else in your organisation hold NatHERS Assessor accreditation?	Yes
6	Impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Industry product availability/cost/quality, Victorian/Australian market transformation? • Design effort? • Construction effort? • Comfort (thermal & acoustic)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Supply Chain? o Construction/fabrication teams? • Developer and consumer awareness, changing market expectations?	• Primary impacts have been an estimated 40% - 50% of new dwellings have been double-glazed – even if there is doubt about the quality of the glazing and framing. • No change to solar passive designs, due to a lack of planning requirements and developers' profit maximisation. This means that consumers are paying more for 6-star than they would have if solar passive designs had been adopted. • Vic houses are not appropriately designed for summer performance, due to well-known/long-standing errors in NatHERS, that suggest lower cooling loads than is actually the case and also unrealistic cooling behaviours. These mean that designs are not optimised for the cooling loads and behaviours that actually occur – leading to significantly higher peak loads and energy consumption than modelled – and/or poor summer comfort outcomes •
7	Experiences of alternative NCC Section J compliance pathways in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	
8	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? E.g.: • Highest star ratings attained? When/why/how?	

	• Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance?	
9	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	
10	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	• SHW known to be of very low quality – questionable whether many systems comply with Australian Standards. There is no effective enforcement of standards, and consumer awareness is very low. • No real experience with watertanks.
11	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	• Non compliance is understood to high, due to commercial model for building surveyors, lack of inspections, unaccredited practitioners. • DELWP/VBA audits will be significant.
12	Renovations: • Do you have any residential renovation energy performance experience outside of houses? • Key observations from your experiences: o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
13	Most significant drivers of change / impacts of change over last decade with respect to sustainable residential design in Victoria?	
14	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Perceptions and estimates of incremental costs are routinely - highly inflated. Cited an example of an industry associating mis-using their work to suggest a $20,000 incremental cost • Actual costs $1,700 - $2,100 •
15	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Current focus should be on zero carbon, not incremental change • Very supportive of Sustainability Victoria's Carbon Neutral Housing project – sees this an excellent way to get industry leaders on board and reduce fears about achieving higher performance • Apply solar orientation considerations for new housing developments

		• Ban single glazing, including for replacements – this will ensure that costs of double-glazing come down over time. • Enforce product as well as building code standards.
16	Do you know the NatHERS rating of the home you live in? How/why?	
17	Any other comments?	

Stakeholder #18

1	Current role?	Energy Assessor, Analyst, Consultant
2	How many years' experience working in residential sector in Victoria?	30+ years
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations?	Mainly higher end houses and apartments
5	Do you, or anyone else in your organisation hold NatHERS Assessor accreditation?	Yes
6	Impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Industry product availability/cost/quality, Victorian/Australian market transformation? • Design effort? • Construction effort? • Comfort (thermal & acoustic)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Supply Chain? o Construction/fabrication teams? • Developer and consumer awareness, changing market expectations?	• There is evidence of 'hot boxes' – attributed to unrealistic set-points in NatHERS, given the impression of low cooling loads when in fact they are higher – will get worse over time due to climate change. Lochiel Park study in South Australia suggests summer set points need to be dropped (in NatHERS) by 2 degrees to replicate actual cooling behaviours and loads. • Constraint factors used in 2009 RIS (the CIE) were unrealistically low, suggesting lower energy savings than is actually the case. • Assumption that 40% of houses are empty during the day, but changing working habits may make that inaccurate. • He is seeing significant reductions in winter heating energy use, but no cooling savings • Insulation and double-glazing do reduce cooling loads – but glazing may be excessive, located West/South and unshaded • Hot box syndrome likely to be worse in apartments – lack of cross-ventilation • There is a variety of strategies being used to meet 6-star across Victoria – at the high end, expensive glazing. Volume builders – some doing small windows; other may not comply; some are doing a great job (cited AV Jennings)
7	Experiences of alternative NCC Section J compliance pathways in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	• Estimates 90% of Victorian dwellings use NatHERS for Code compliance • Use of alternative solutions is spreading (started in WA) and lead to very low star rating outcomes (estimated could be as low as 3.5)

8	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? E.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance?	
9	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	
10	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	
11	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	
12	Renovations: • Do you have any residential renovation energy performance experience outside of houses? • Key observations from your experiences: o Process? O Effort and cost vs. value? O Potential improvements to compliance standards/processes?	
13	Most significant drivers of change / impacts of change over last decade with respect to sustainable residential design in Victoria?	• 6-stars is too low to have forced any significant design changes • Solar passive still rare • There is little customisation of plans, and volume builders deliberately build designs that are insensitive to orientation, to minimise rating and redesign effort across blocks • Voluntary efforts often go to 7.5-stars or more
14	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	• Poor enforcement of standards • Has discovered fake QR codes on Universal Certificates • Unaccredited assessors are common

		• Architect designed houses struggle to comply – often very large and highly glazed. Ends up costing a great deal – but clients seem happy to pay! • Tendency to over-glaze. Little awareness that excessive glazing, even on a northern façade, can create significant performance problems, including over-heating even in winter.
15	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	• Should be thinking about zero net energy/emissions homes – focus on the overall case and not only the incremental cost. Claims that 8 stars plus zero net energy is cost effective – avoided energy costs exceed annualised additional mortgage payments • Should encourage batteries for grid benefits • For apartments, 5-star minimum, 6-star average, was an industry compromise with no good justification • Enforce the Code, regardless of the star rating requirement • Key example where industry practices have changed is waffle-pod slabs – no additional cost on average (can be savings, can be extra, depending on the site – also, less siteworks and less construction time) for ½ star. This was not taken into account in the 2009 RIS
16	Do you know the NatHERS rating of the home you live in? How/why?	
17	Any other comments?	

Stakeholder #19

1	Current role?	RMIT, A2EP etc
2	How many years' experience working in residential sector in Victoria?	40
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	35
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations/extensions?	• 65% • 5% • 10% • 20%
5	Do you, or anyone else in your organisation hold: • NatHERS Assessor accreditation? • AFRC Simulator accreditation?	• No
6	Experiences of alternative NCC Section J compliance pathways for new-builds in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	Little for me as I have always worked with leading edge, exceeding compliance. Impact depends on how you do it! Note many builders already exceed 6-star for at least some of their projects because they use 'bullet-proof' designs that can cope with a range of orientations etc
7	Supply chain impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? e.g. window and insulation technologies/trends, solar hot water, solar PV, lighting, verification technologies etc. • Victorian industry product availability/cost/quality? • Australian industry product availability/cost/quality? • Overseas industry product availability/cost/quality? • Adaptation periods? • Impact of other factors e.g. exchange rates, other regulatory influences?	Elemental is fundamentally more expensive, though elemental minima eg for glazing could drive economies of scale cost reductions. Verification is easily gamed: should be linked to tighter inspections and formal monitoring of actual performance over time to allow for comparisons, and 'make good' provisions. Tighter protocols, too.
8	Other impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Design effort? • Construction effort? • Comfort (e.g. both thermal & acoustic drivers of increased glazing/insulation specs)? • Compliance rates? • Overall costs and quality?	NatHERS 8 star for apartments in 2003. My advice is usually early in design stage or for renovations. For apartments, major factor affecting difficulty is orientation of single façade. Summer overheating is a major issue now being addressed through planning schemes, and hopefully in future through NCC but still weak. I prefer use of the NatHERS feature where you can look at free-running zones/rooms for a hot week and a cold week to see which parts of the building may be problems.

	• Industry adaptation periods? o Design teams? o Construction/fabrication teams? • Developer and consumer/owner awareness, changing market expectations?	
9	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance? • Incidental overcompliance causes?	Was on Plumbing Industry Advisory Council for a period. Very high callback and poor installation rates. I am very sceptical about the long term performance of many solar HWS, especially gas boosted ones which are complex and, due to legionella rules, complex and inefficient. I suspect many fall far short of the minimum 60% solar contribution. The focus on gas boosting adds to costs and fails to recognise PV, scope to manage timing of heat pumps, etc.
10	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	There is very poor enforcement and CSIRO's finding of poor delivered outcomes. I have never seen any study of actual gas consumption of solar-gas HWS in the field and over time.
11	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	No consequences as far as I can see – unless flammable cladding was sed – in which case the cost seems to fall on the present owners instead of the builder/designer/regulator/inspector and governments, including customs inspectors.
12	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	Very difficult to ensure compliance – fragmented processes, many tradies, many changes during projects, often multi-stage small renos end up with big changes. On the other hand, a lot of customising, so tradies who want to do good things can influence outcomes.
13	Post-construction phase: • Have you been involved in projects where there has been on-site verification of integrity e.g. thermography, air-tightness testing, window performance etc.? • Have you ever received **post-occupancy** feedback from occupants and/or construction team?	NCC, ongoing innovation to cut costs and tweak performance without having to make big changes to designs or practices, or to incorporate EE into low cost innovations with other benefits/cost/practice savings and high profile measures that attract more customers or 'add value' or point of difference to the packages they are offering. Into the future, improving data analytics will shake things up.
14	Renovations: • What proportion of your residential renovation experience relates to houses? • Key observations from your experiences of Clause 9.3.2 of VBA *Practice Note 2014-55 – Residential Sustainability Measures* and *Victoria Building Regulation 233 (50% rule).* o Process? o Effort and cost vs. value?	Fragmentation of processes, responsibilities and industry/institutional structures. Focus on visible features, excessive focus on gas (historical). Focus on 'sticker price' of housing not cash flow over time. Lack of focus on multiple benefits and properties built for rental.

	o Potential improvements to compliance standards/processes?	
15	Most significant drivers of change / impacts of change over last decade or so with respect to sustainable residential design in Victoria?	Manufactured housing will be important. And shifting away from ducted central space conditioning.
16	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	I think it's about 6 from self-assessment, but it has features NatHERS rating doesn't give full credit such as surrounding vegetation simple removeable shadecloth over courtyard, external roller shutters (white) etc.
17	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	Existing buildings and rental properties are key. Consideration of multiple benefit – health, amenity, productivity, location etc all matter a lot – as reflected in outcome of recent Energy Consumers Aust summit. Lack of training of architects and building designers is still a big problem. Maybe designers should be required to get certification in NatHERS rating if they design more than a minimum number of buildings a year. Or there should be a much higher profile for clients to see that this home was designed by a certified expert….. Integration of healthy design (eg condensation mgt) should also merge with EE. I am also concerned about how 'whole of home' building codes and ratings could undermine focus on building envelopes unless it is well-planned. The fabric lasts a long time and influences health, resilience etc.
18	Do you know the NatHERS rating of the home you live in? How/why?	
19	Any other comments?	SHW heaters as installed are inherently inefficient, due to cold water tempering and standing losses.

Stakeholder #20

1	Current role?	Head of Policy, Industry Association
2	How many years' experience working in residential sector in Victoria?	20+ years, but in representative roles. EEC has some members involved in insulation manufacturing, and some in installing, but mainly commercial rather than residential builders.
3	Interstate/overseas experience in the residential sector? (Jurisdictions & periods?)	
4	What proportion of your industry experience regarding residential energy performance relates to: • Houses? • Townhouses? • Apartments? • Renovations?	EEC is a generic interest group for all energy efficiency services – the residential sector is a relatively small focus for them.
5	Do you, or anyone else in your organisation hold NatHERS Assessor accreditation?	No.
6	Impacts of Victoria's unilateral change from 5* to 6* NatHERS minimum threshold? • Industry product availability/cost/quality, Victorian/Australian market transformation? • Design effort? • Construction effort? • Comfort (thermal & acoustic)? • Compliance rates? • Overall costs and quality? • Industry adaptation periods? o Design teams? o Supply Chain? o Construction/fabrication teams? • Developer and consumer awareness, changing market expectations?	The EEC supports strengthened energy efficiency standards in buildings and appliances and equipment, but preferably on an Australia-wide basis. It is not aware of any particular difficulties or complaints from industry regarding 6-star or plumbing regulations, due to limited representation in the field. Similarly, he could not comment on beneficial experiences, rates of cost reduction, etc. They have no members who are windows manufacturers.
7	Experiences of alternative NCC Section J compliance pathways in Victoria e.g.: • Elemental Deemed-to-Satisfy (DtS)? • V2.6.2.2 verification modelling compliance?	

8	Experience designing/delivering beyond 6* NatHERS ratings, and/or other relevant minimum standards? e.g.: • Highest star ratings attained? When/why/how? • Green Star, BREEAM, Passivhaus experience etc.? • Practical stringency differences between apartment/townhouse and house NatHERS compliance/exceedance?	
9	Involvement/experience of decision-making processes between solar hot water system vs rainwater tank vs 3rd pipe installation in new Class 1 home compliance with VBA Practice Note 2014-55?	
10	Experience (and consequences, if known) of instances of NatHERS/Section J/VBA Practice Notes non-compliance?	
11	Experiences of the role of building surveyors in the compliance process? Application of NCC/VBA Section J dispensations?	
12	Renovations: • Do you have any residential renovation energy performance experience outside of houses? • Key observations from your experiences: o Process? o Effort and cost vs. value? o Potential improvements to compliance standards/processes?	
13	Most significant drivers of change / impacts of change over last decade with respect to sustainable residential design in Victoria?	
14	Biggest obstacles to progress / loopholes, unintended consequences: • Regulatory anomalies? • Design/Tender/Construct/Certify processes? • Awareness levels and urban myths?	Length of time since last Code upgrade is excessive. The process for changing/updating building regulations is not clear or transparent. Why has there not been more industry engagement around this?

15	Have you observed any low-cost/effort opportunities for change that might improve industry status quo?	
16	Do you know the NatHERS rating of the home you live in? How/why?	No
17	Any other comments?	Suggests ASBEC should be consulted. Also suggests a more efficient process would be to convene a workshop of all relevant groups operating in the energy efficiency area, to brief them on the process. Written comment required?

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