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1 Executive Summary

This report details a range of technical modifications to both the method and underlying assumptions underpinning the modelling of benefits and costs associated with the proposed new NCC residential energy efficiency provisions for introduction in 2022. These modifications have been undertaken subsequent to the publication of the Consultation Regulation Impact Statement (CRIS) and are a response to comments received during the CRIS consultation and a detailed internal review of the original modelling assumptions.

The key modifications for application to the analysis undertaken for the Decision Regulation Impact Statement (DRIS) were:

1. *Optimisation of expected design solutions*: Analysis revealed that the expected response of the building industry to the proposed regulations that was used in the CRIS analysis was not comprehensive enough to deliver the most optimal results. A revised design optimisation process was developed that considered a much broader range of cost effective compliance options, which is considered to be more representative of the workings of the industry.
2. *Amendments to the assumed level of small-scale technology certificate (STC) credits for PVs:* Accounting for STC credits in relation to PV installations had been calculated for the CRIS based on a deemed lifetime of 4 years (i.e. the expected average credit period over the lifetime of the regulations 2022-2031). The CRIS model was however set up to use as its input the deemed lifetime in year 1 of the regulations (i.e. a deemed lifetime of 8 years) rather than the average. The credits were therefore revised upwards.
3. *Amendments to the assumed propensity of gas heating in Victoria*: The assumed propensity of gas heating in new Victorian houses was amended (increased) to better align with estimates provided by the Victorian Department of Environment, Land, Water and Planning (DELWP).
4. *Factoring in of the impact of the outdoor living area (OLA) provisions of NCC 2019*: In the original CRIS analysis, the impact of OLA provisions of NCC 2019 were not factored into the calculations. These provisions reduce the cost of compliance for those dwellings that include an OLA (NCC climate zones 1 and 2 in Qld, NT and WA). This omission was remedied for the decision RIS analysis.
5. *Factoring in of the impact of the NCC 2022 elemental provisions:* The proposed elemental provisions are based on achieving close to a 7-star performance in each climate zone. The newly refined elemental provisions are expected to lower costs in 2022 for the 20% of dwellings (nationally) that use the elemental provisions. These savings have now been factored into the decision RIS analysis.
6. *Revised Costs associated with Class 2 PV installations*: In the CRIS analysis it was assumed, that the cost of installing PVs into a class 2 dwelling would impose on average a cost impost of 25% over and above that observed in relation to larger class 1 installations. Subsequent more detailed analysis determined that the expected cost impost could range significantly but that a conservative estimate would be in the order of a 50%. This additional cost has been factored into the decision RIS analysis.
7. *Adjustments to assumed propensity and capacity of PVs installed into class 1 base case dwellings* : For the CRIS analysis, estimates were made of the propensity of base case class 1 dwellings that were fitted with PVs as well as the average capacity of those PV installations. These estmates were based on available data covering Victoria only. Subsequently the data base was updated and extended to also include data from NSW/ACT and Queensland. The updated data suggested that the PV capacity assumption should be increased from 5kW to 6kW except in Qld where 7kW is the norm.
8. *Including benefits from addressing thermal bridging issues:* Whilst the cost associated with addressing thermal bridging were included in the CRIS economic analysis the benefits in terms of reduced heating and cooling loads and consequent reduced space conditioning operational costs were not factored into the analysis undertaken by CRIS. These benefits have now been factored into the decision RIS analysis.

This report also includes a dissertation on design response limitations specific to class 2 dwellings and an exploration of using an alternative benchmark setting for class 2 dwellings in Queensland.

2 Introduction

This report prepared by Tony Isaacs Consulting (TIC) and Energy Efficient Strategies (EES) details a range of technical modifications to both the method and underlying assumptions underpinning the modelling of benefits and costs associated with the proposed new NCC residential energy efficiency provisions for introduction in 2022. These modifications have been undertaken subsequent to the publication of the consultation regulation impact statement (CRIS) and are a response to:

- comments received during the CRIS consultation
- a detailed internal review of the original modelling assumptions particularly in relation to likely responses to the proposed regulations

The updated modelling described in this document will be used in the Decision RIS (DRIS).

ACIL Allen consulting were commissioned by the ABCB to undertake the economic modelling for the proposed regulatory changes.The original technical analysis prepared by TIC and EES was fed into the ACIL Allen main economic model in order that the results as reported in the CRIS could be derived. The ACIL economic model is however very complex and time consuming to use (a single run can take several days to set up and run). So that the various modifications detailed in this report could be subjected to a preliminary assessment in a timely manner ACIL Allen developed a quick assessment tool designed to deliver a broadly comparable economic assessment to the CRIS but in a fraction of the time. This tool is known as the "Ready Reckoner" and is described further in the following section. The impact of changes to the modelling methods and or underlying assumptions were initially gauged individually using the ready reckoner tool to establish the likely significance of each change. The full suite of agreed changes were then applied to the ACIL main economic model to calculate a revised set of economic impact assessment outputs to be used in the DRIS.

The various modelling modifications/refinements examined in this report can be summarised as follows:

1. Revised optimisation of expected design solutions
2. Amendments to the assumed level of STC credits associated with PV installations
3. Amendments to the assumed propensity of gas heating in Victoria (Class 1)
4. Factoring in of the impact of the outdoor living area provisions of NCC 2019
5. Factoring in of the impact of the proposed new glazing calculator in the NCC elemental provisions
6. Revised Costs associated with Class 2 PV installations
7. An investigated option of re-setting of benchmark equipment assumptions (Qld)
8. Adjustments to assumed capacity of PVs installed class 1 base case dwellings
9. Accounting for design response limitations specific to class 2 dwellings
10. Including benefits from addressing thermal bridging issues

Each of the above noted modifications/refinements impacted to a greater or lesser extent on either the expected costs (either higher or lower) and or the expected benefits (either higher or lower) of the proposed regulations. The overall net effect of all of these amendments being an improvement in the observed benefit to cost ratio outcomes.

3 ACIL Allen Ready Reckoner model

As noted in the introduction, ACIL Allen has developed a "ready reckoner" tool to assist with assessing the likely economic impacts of the various modelling modifications/refinements examined in this report[1]. And, in particular, the Benefit/Cost outcomes, primarily at a household level.

The ready reckoner tool is not as sophisticated as the main analysis tool so the results obtained using this tool are not exactly the same as those produced by the main analysis tool. To deal with such discrepancies a analysis was undertaken using the original CRIS input data set, first input into the ACIL Allen main modelling tool and then input into the Ready Reckoner (RR) tool. The comparative results at a national level are shown below in Table 1.

The National level weighted Benefit Cost Ratio (BCR) values of the RR (columns 4 and 5) are generally within approximately 10% of the results obtained by the main model (class 1 option B was in the order of 20% different). For class 1, the RR gives lower BCR results than the Main model except in Victoria where the BCR was found to be somewhat higher in the RR (changes subsequent to the CRIS analysis made by ACIL Allen to the Victorian feed in tariffs is likely to be driving this reverse trend observed in relation to Victoria). For class 2, results from the RR in each jurisdiction were found to be consistently 7 – 9 % lower than that from the ACIL main model.

By dividing the value obtained in the ACIL Allen main model by that obtained in the ready reckoner a set of adjustment factors were derived (see columns 6 and 7 of the table). These factors (calculated at each jurisdictional level) were used to adjust the results coming out of the Ready Reckoner such that they would give a closer match to the results that come out of the ACIL main model.

Table 1 Comparison: ACIL Main Economic Model V ACIL Ready Reckoner

	ACIL Main CRIS Table 7.1			ACIL R Reckoner Result			ACIL Main / RR	
Case	Option A	Option B		Option A	Option B		Option A	Option B
	BCR	BCR		BCR	BCR		BCR	BCR
Class 1	**0.80**	**0.70**		**0.73**	**0.58**		**109%**	**121%**
Class 2	**0.53**	**0.55**		**0.49**	**0.51**		95**%**	**108%**

4 Revised optimisation of expected design solutions

A key set of assumptions that underpin the estimates of benefit and cost relate to the nature of the expected response of the building industry and home owners to the proposed regulations. The concept of whole of house energy performance regulations is new to most Australian jurisdictions (noting however that NSW has operated a form of whole of house regulatory tool known as BASIX) and at this stage there are not even any approved NatHERS simulation tools for industry to use (these are scheduled to come on line later in 2022), so there is little experience and significant uncertainty as to how industry/homeowners will respond.

[1] Note that the ready reckoner model was used to guide improvements made to modeling (as outlined in this report), but was not used to cacluate the final results presented in the Decision RIS. ACIL Allen's full enconomic model was used to calculate the final results. The full model is significantly more comprehensive but as a consequence takes many days to run, which is why the ready reckoner was developed. The ready reckoner allowed for fast results, and a more iterative process.

Naturally, it would be expected that compliance pathways will tend toward the lower capital cost options but this will not always be the case. One only has to consider responses to the current regulations that do not represent lowest capital cost pathways such as:

- the high proportion of builders/homeowners that elect to exceed the minimum performance standards in the NCC (generally 6 Stars).
- the 20-30% of new dwellings that are built with PVs despite the fact that they are not a regulatory requirement.
- the popularity of heat pump space heaters despite the fact that resistance electric type heaters have a lower capital cost.

Clearly initial capital cost is considered up to a point, but longer term cost effectiveness is also a consideration for many.

In the analysis that the CRIS based its costs on, a relatively simplistic approach was taken to this question of likely response to the regulations. This is covered in detail in section 8 of the *NCC 2022 Update Whole-of-Home Component* and in particular in section 8.9. In summary three main options were considered:

1. Simply retaining the business as usual (BAU) equipment selection and applying as much PV as is required to meet the particular regulatory stringency level.
2. Altering the equipment selection only (i.e. no added PV – this option is possible in the case of stringency option B and in selected cases under option A).
3. Altering the equipment selection plus adding as much PV as is required (if any) to meet the particular regulatory stringency level.

Option 1 may be appealing to those that are resistant to changing their preferred current practices in relation to equipment selections but tends on occasion to lock in some less cost effective equipment choices.

Option 2 tends to require the use of relatively high end (costly) equipment but was a necessary option to include in relation to class 2 and difficult (overshadowed) blocks where inclusion of PV was deemed not to be an option.

Option 3 represents a hybrid approach but naturally there could be many combinations of equipment type and PV capacity that could form a compliance solution, so, for the CRIS analysis a very simplistic assumption was used in the initial analysis whereby it was assumed that in all cases:

- heat pump space conditioning and
- heat pump water heating (+ PV as required)

would be used as an alternative to the BAU equipment choices.

A review of the application of this approach to the ACIL Allen CRIS analysis methodology revealed that the approach was overly simplistic and particularly in the case of class 2 dwellings failed to deliver the most optimum results in terms of costs and benefits.

In the case of dwellings without heating or cooling the approach was generating a somewhat unlikely outcome where in many cases it was assumed that heating/cooling equipment would be installed as a means for compliance (thereby increasing both capital costs and increasing operational costs). In reality, minor improvements to the building shell performance or the water heater performance could achieve a compliant result at a far lower capital cost and without the added operational cost of a heater/cooler.

To solve these issues a new "optimisation" routine was developed in the analysis tool. This new optimiser allowed for all practical solutions[2] within the modelled cases (77 combinations of heaters/coolers and water

[2] Naturally not every possible heater/cooler/hot water combination could be used in every case. For example, it was assumed that appliance service levels would not be reduced, that gas appliances could only be used in the compliance

heaters combined with PV as/if required were modelled in each jurisdiction/climate zone) to be considered as potential compliance solutions for each case examined. Each optimisation was unique to each jurisdiction because fuel prices and feed in tariffs (that vary from jurisdiction to jurisdiction) can be a significant determinant of what constitutes an optimal solution in terms of the societal cost metric.

The revised optimisation approach considers a much broader range of compliance options which is considered to be more representative of the workings of the industry. This approach has resulted in improved benefit/cost outcomes.

It should be noted that this revision to the analysis involves no changes to any of the underlying assumptions or calculations relating to energy savings achieved by the various upgrade options or to the assumed unit cost of building shell upgrades or equipment costs, as currently detailed in the CRIS documentation.

Improvements in benefit / cost outcomes are derived from a better optimised compliance pathway selection procedure. Whilst the new optimisation process is more nuanced and sophisticated than that used in the CRIS analysis it is still working with a limited range of options and industry should be expected to achieve even better benefit cost outcomes by drawing on an even broader and more nuanced range of compliance options available through the new NatHERS WoH tools. This would be particularly true where a certain combination of choices in this studies' analysis just falls short of compliance. In such cases it may only require shifting from a 7 star building shell to 7.1 stars[3] or from a 3 star heat pump air-conditioner to a 3.1 star heat pump air-conditioner[4] or from a water heater with 25 RECs to one with 28 RECs to achieve compliance (at lower cost than the model currently assumes). Such granularity of available options is not however available in the modelling undertaken for this project[5].

As noted earlier in this section, optimisation can be based on a number of perspectives. The two main perspectives usually considered are lowest initial capital cost and lowest lifetime cost. A rational consumer with relevant information would be expected to select the most cost effective solution. Those wishing to only sminimise cost would select the lowest initial capital cost solution. In reality, at the bottom end of the market minimum cost would be expected to be more important but for the rest of the market cost and cost effectiveness will often be both considered.

For the analysis undertaken in this study only the lowest capital cost option was assumed thereby making the benefit cost analysis somewhat conservative. Nevertheless, the improved optimisation process produced improved benefit cost outcomes particularly in relation to class 2 dwellings.

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pathway if there was already a gas heater and or a gas water heater in the base case. Wood heating could only be used if it was already being used in the base case etc. In total there were about 17 such rules that needed to be applied in the optimisation process to help ensure an accurate reflection of expected industry/homeowner behaviour (these newly applied rules are summarised in Appendix 1 at the end of this document). It should be noted that some of these rules can in some cases actually result in higher costs than would otherwise be the case without these rule due to the limitations they impose, nevertheless, these rules are considered realistic and even with these additional rules there is a net improvement in benefit cost outcomes as a result of the more sophisticated and nuanced optimisation method.

[3] There is already over compliance observed in Class 2 buildings in Australia. This often arises from developers wanting to use the same building fabric specification to all units.

[4] Note: The modelling undertaken only modelled at selected star band threshold performance levels (e.g. 3 GEMS old stars = 375% efficiency). In fact a three (old) star rated air-conditioner can have a performance of anywhere between 3 stars and 3.49 stars or 375% to 400%. The analysis in this study therefore assumes the poorest possible performance available at any given star band modelled.

[5] Note: when finalised, the tools developed for NatHERS batch runs will be able to do this and will greatly improve the sophistication of analysis for future projects.

5 STC credits for PVs

Solar rebates, or Small-scale Technology Certificates (STC credits), for PV installations are in part based on the deemed life of the installation. Under current arrangements, for the purposes of calculating credits, all PV installations are deemed by the Clean Energy Regulator to persist until 2030. This means that over time, the lifetime multiplier used to calculate credits (rebates) will decline from 8 years in 2022 to zero by 2030 (i.e. effectively no rebate post 2030)

In the original CRIS modelling technical analysis (that fed into the ACIL Allen economic analysis model), the applicable lifetime of STC credits for PV installations was set to a period of 4 years. This value was based on an averaging of the deemed years of persistence over an assumed 10 year life of regulations (i.e. average over the period 2022 to 2031). It was however subsequently determined that the ACIL Allen model was in fact set up to take as its input the rebate level as applicable in year one of the regulations and not the average over the assumed life of the regulations (i.e. 8 years of credits rather than the 4 years that was in fact being used) as the ACIL Allen model was already factoring in the expected changes in both rebates and system capital costs against that input value. Effectively this meant that there was a double counting of the diminution over time of PV rebates which tended to over-estimate the net cost of PV system installations at a household level.

To avoid this double counting, the assumed lifetime of STC credits for PV installations was increased from an average of 4 years to a starting year value of 8 years.

The net result of this change was to improve start year class 1 BCRs, ranging from 1% to 10% depending on jurisdiction with an average improvement of 6% nationally.

6 Baseline gas heating penetration in Victoria

As part the CRIS consultation process the Victorian Department of Environment, Land, Water and Planning (DELWP) provided 2 recent sources that include estimates of the propensity of heating/cooling and hot water equipment in that state (under the status quo); analysis undertaken by Energeia for DELWP in 2021 and the final report for the Evaluation of the Victorian 6-star Housing Standard- Final Report (Ark/SPR 2019).

Generally the estimates for appliance propensity in these studies align reasonably well with those used in the CRIS, however, there are significant differences in relation to the estimates for gas heating going into new class 1 dwellings in Victoria. The CRIS uses a very low estimate (7%), the Ark/SPR study estimates closer to 40% and the Energeia study estimates close to 70%.

It is fair to say that available survey data of new dwellings to support any of these estimates is limited. A review of data sources used in the Energeia study revealed that those estimates were almost entirely based on surveys of the stock of all Victorian housing and not a survey of newly built housing. What is now going into new class 1 housing in Victoria in terms of heating equipment is different from what is in the stock of housing with a known shift over the past 10 or so years away from gas heating in favour of reverse cycle heating/cooling. The magnitude of this shift is however in question.

The analysis undertaken for the CRIS used a number of sources to try and estimate the propensity of gas heating in new housing. This included:

- ABS data (stopped in 2014)
- BIS Oxford Economics data

- Data from Basix portal data
- Data from Built Environment Sustainability Scorecard (BESS) scheme (see https://bess.net.au/)

Full documentation and details of this analysis are contained in the NCC 2022 Update Whole-of-Home Component Report (Appendix 6) that sets out data sources and assumptions. For Victoria this analysis determined that for new class 1 dwellings the propensity of gas heating was at 7% and for class 1 at 3.6%.

Representations from DELWP during the consultation period suggested that whilst the assumed value for class 2 was about right the value for class 1 was significantly lower than expected and that this was likely driven by a sampling bias in the BESS data.

It was agreed that the following values for Victoria would be adopted:

- Class 1 = 65.5% [6]
- Class 2 = 5%

This adjustment made a not insignificant difference (improvement) to the BCR outcome for class 1 dwellings in Victoria.

7 Outdoor living areas

7.1 Overview

In the original CRIS analysis the impact of the outdoor living area (OLA) provisions of NCC 2019 were not factored into the calculations. These existing provisions are expected to reduce the cost of compliance with the proposed NCC 2022 regulations for those dwellings that included an OLA. This impacts those dwellings built in NCC climate zones 1 and 2 in Qld, NT and to a very minor degree in WA.

Depending on the location, the presence of an OLA reduces compliance cost in respect of the building shell requirements by between 30% - 60% and is applicable to between 20% and 30% of dwellings. Overall, across the entire stock of new dwellings in these locations, weighted average building shell compliance costs drop by between 12% and 14%.

This change resulted in only modest improvements in BCR outcomes ranging from 2 to 5 percentage points of improvement in Queensland and NT to less than one percentage point improvement in WA.

Note: For the purposes of this analysis it was assumed that a 6-star dwelling with an OLA will have an equivalent energy use as a 7 star dwelling without an OLA.

7.2 Number of dwellings affected by Outdoor Living Area (OLA) concession

The Australian Housing Data (AHD) shows the number of dwellings in Climate Zones 1 and 2 submitted to the portal with a rating of less than 6.0-stars. It is assumed that ratings below 6-stars will all be using an OLA to gain a building approval. This data is shown below.

Table 2 Proportion of dwellings obtaining less than 6-stars in the current market assumed to use the OLA concession

Climate	<5.0 stars	5-5.5 stars	5.5-6.0 stars
Darwin	0%	7.33%	15.64%
Cairns	0.26%	11.16%	8.18%

[6] This represents the weighted average for all class 1 (based on the CSIRO portalproportion of class 1a(a) = 76.6% and 1a(b) = 23.4% in Victoria)

Climate	<5.0 stars	5-5.5 stars	5.5-6.0 stars
NCC Climate zone (CZ) 01	0.38%	8.22%	7.62%
Brisbane	4.45%	17.39%	10.60%
CZ 02	3.65%	14.40%	9.80%

The OLA provides both more than just a way to reduce energy consumption, it effectively extends the usable area of the house for much less than the cost of an enclosed area.

To deliver energy savings equivalent to NatHERS 1-star, the occupant would have to actively not use cooling but seek out the more comfortable conditions in the OLA. While it is "common sense" to do so, there is no research into the use and energy saving potential of an OLA.

The proportion of dwellings using the OLA concession is assumed to be the proportion of dwellings which achieve less than 6-stars as shown in the CSIRO portal, and the energy saving achieved will be equivalent to 1-star. Five stars is the average rating of all the dwellings with ratings below 6-star in these climates.

The higher cost of 7-stars may see the proportion of dwellings using an OLA may increase in future, so the assumption that the proportion remains the same is conservative.

7.3 Cost savings

The Class 1 RIS costs and benefits were assessed using six dwellings on a slab and timber floor (for details of design features see SBH01-06 in Appendix 2 of the *Costs and Benefits of Upgrading Building Fabric from 6 to 7 Stars -Tony Isaacs Consulting*). The RIS compares the average improvement costs for these dwellings with the energy savings from the dwelling with average heating and cooling energy use called the composite dwelling in the RIS: SBH05. House SBH04 was also a closely match matched the average heating and cooling loads, but was slightly smaller than house SBH05. Because it has a compliant OLA, it was selected for the evaluation of the costs with an OLA. It is a 4 bedroom home with two living areas and a double garage. It has a Gross Floor Area of 197.5 m^2 and a Net Conditioned Floor Area of 127.1 m^2 (slightly smaller than the average from the AHD). The plan has been included in Appendix 3.

The cost savings below are based on SBH04 because this house had an OLA. SBH04 has a very similar energy load to the composite house, SBH05, and was the initial choice for use as the composite house. The cost per square metre of upgrading SBH04 from 6- to 7-stars is similar to the average across all dwellings.

Table 3 Comparison of cost increase from 5 to 6 and 6 to 7 stars

Star Rating change	Darwin		Cairns		Brisbane	
	Slab	Timber	Slab	Timber	Slab	Timber
6 to 7	$724.50	$1,745.43	$1,108.95	$647.68	$402.37	$719.60
5 to 6	$294.91	$1,142.34	$449.33	$380.27	$248.60	$510.33
Percentage reduction	41%	65%	41%	59%	62%	71%

There were a number of assumptions made about the way in which 5-stars was achieved that may mean the cost reductions shown above are conservative, i.e. are an underestimate:

11. It was assumed that window area at 5 stars would be larger than 6-stars as consistent with the AHDAHD The increase in window area is around 7 m^2, or an increase of 19%. The increased window costs offset some of the reduced cost of insulation and high-performance glazing etc. that dropping the rating to 6 stars allows.
12. Note in Darwin and Cairns if you have a reflective roof space, i.e. reflective foil under the roof material, ceiling insulation in bedrooms and utility areas may not be needed at 5 stars. The AHD shows that 28% of ceilings are not insulated at 5 stars in QLD. Results in the NT are not clear. If

bedrooms and utility areas did not need ceiling insulation at 5-stars, it was not included. In houses where all ceilings are insulated at 5-stars this assumption will mean the cost reduction shown above is underestimated.

13. 5-star dwellings were assumed to have the same number of ceiling fans as 6-star dwellings because the installation of fans in all houses is high in climate zones 1 (average 8 for all ratings levels) and 2 (average 5 for all rating levels).

8 Factoring in of the insulation provisions and new glazing calculator

8.1 Overview

The NCC 2022 elemental provisions are based on achieving close to a 7-star performance in each climate zone. This new development has resulted in several changes to elemental compliance, which is expected to lower costs in 2022 for the 20% of dwellings (nationally) that use the elemental provisions.

These cost reductions have now been factored into the modelling for this cohort of dwellings and has consequently lowered compliance costs overall and modestly improved BCRs for Class 1 dwellings only.

These cost savings arise from the following changes:

- Elemental insulation requirements provide many opportunities to install less insulation than would be required by NCC 2022 ***IF*** the other properties of the building element are better suited to the climate. For example, a lower level of wall insulation can be used in a hot climate if the wall has a low solar absorptance (light colour) and/or sufficient shading and vice versa in a cool climate, and
- The development of the glazing requirements showed that many of the dwellings which obtained 7-stars in NatHERS would have failed the 2019 Glazing Calculator (GC). Because the NCC 2022 GC is calibrated to achieve a 7-star outcome on average, this means the 2022 GC will not require the same level of high-performance windows as the 2019 GC.

Cost savings due to lower insulation requirements are less certain because building element properties like solar absorptance, i.e. colour, are aesthetic choices. While lower insulation levels are available, the market may not choose the lowest cost option, which means the same or higher insulation levels would be used. This section, therefore, focuses on the impact on window performance.

The 2022 GC, which correlates to 7-stars, will both lower compliance costs compared to NCC 2019 and deliver lower energy savings. This section examines the relative cost and energy saving changes to determine the extent to which the new NCC 2022 GC will improve the BCR for NCC 2022 elemental provisions.

Note that no Class 2 elemental provisions are included in NCC 2019, so this work only applies to Class 1 dwellings.

8.2 The extent of use of elemental provisions

The AHD records the number of NatHERS Universal Certificates issued every month and the monthly ABS Building Approvals (ABC cat. No. 8731.0). While there may be a delay between issuing the NatHERS Universal Certificate (UC) and issuing a building permit, long-term trends should even out monthly mismatches. The following table shows the number of Class 1 NatHERS Universal Certificates issued since May 2016 with the number of building permits issued over the same time period:

Table 4 Proportion of building permits using NatHERS since May 2016

Jurisdiction	NatHERS UC as a percentage of building permits	Final % of dwellings assumed to use elemental provisions
ACT	78%	30%
NSW	84%	24%
NT	102%	8%
QLD	62%	44%
SA	37%	67%
TAS	106%	5%
VIC	103%	7%
WA	23%	79%

Some jurisdictions record that NatHERS UC numbers are more than 100% of building permits issued. While it is unclear exactly why this would be so, it is presumed to stem from factors such as revisions to plans that result in issuing more than one UC for the same dwelling or where a UC is issued, but the project does not go ahead. Regardless of the reason, it is clear that if the percentage is above 100%, the vast majority of dwellings appear to be using NatHERS in these jurisdictions.

This factor probably affects all jurisdictions, not simply those with certificate levels above 100%. In the absence of more definitive data on these issues, the proportions shown above have been reduced by 10%. It is unlikely that NatHERS represents 100% of building permit applications. Even in jurisdictions where the use of NatHERS is very high, there will still be some permit applications for relocatable buildings which are understood to use elemental provisions. This impact of the 10% reduction in assumed NatHERS use is shown in the last column of the table above (and explains why the two columns do not add up to 100%).

Simply because NatHERS UC numbers are low does not mean that all the remaining dwellings are using elemental provisions because they may be using other methods of demonstrating compliance, such as the Verification Method (VM). It is understood that in SA and WA, the use of the VM is much higher than in other jurisdictions, although there are no statistics on the use of VM in these climate zones. In the past NatHERS tools were being used for the VM, and users were not generating a UC, even though they used NatHERS tools because they were not generating a DtS NatHERS 6-star compliance solution. The star rating levels achieved when using the VM and the extent of use of NatHERS for VM is unknown.

The use of NatHERS in the VM was never intended when the regulations were developed and has since been disallowed, because it might lead to lower star ratings than the regulatory requirement. Therefore, it is presumed that the star rating of dwellings that use the VM may have achieved levels below 6-stars for there to be a cost advantageto reduce construction costs. ***It is problematic in WA and SA to assume that the high proportion of stock shown in the table above would be as shown in the table above. For the purposes of this evaluation, the proprtion of dwellings using elemental is therefore assumed to be the average of other states: 22%.***

In other jurisdictions, however, the VM is not known to be used at the high levels that anecdotal evidence suggests for SA and WA, so the application of elemental provisions in other jurisdictions is as shown in the table above.

8.3 Cost savings compared to NCC 2019 due to Glazing Provisions

In the development process for the 2022 GC, TIC and Graham Energy input the window properties for each 7-star compliant dwelling into the 2019 GC. This analysis showed that most of the 7-star compliant dwellings would have failed the 2019 GC. Because the 2022 GC was designed to set the pass mark for Winter and Summer for dwelings with the average window properties of 7-star dwellings, it follows that the 2019 GC is more stringent than the 2022 GC. Consequently, the 2022 GC will provide cheaper glazing compliance options than the 2019 GC. The table below shows the average summer and winter performance for 7-star detached dwellings in the 2019 GC. If the performance is over 100% in either season, the 7-star dwelling fails the 2019 GC.

Table 5 Average Performance of 7-star detached dwellings in the 2019 GC

Location	Floor	2019 Summer Target	2019 Winter Target
Darwin CZ01	Slab	***122%***	N/A
	Timber	***123%***	N/A
Brisbane CZ02	Slab	***117%***	76%
	Timber	***150%***	70%
Longreach CZ03	Slab	***125%***	***106%***
	Timber	***169%***	94%
Mildura CZ04	Slab	91%	***138%***
	Timber	***119%***	***105%***
Sydney CZ05	Slab	76%	86%
	Timber	91%	80%
Perth CZ05 with brick cavity walls	Slab	76%	90%
	Timber	***108%***	84%
Melbourne CZ06	Slab	56%	***184%***
	Timber	74%	***157%***
Hobart CZ07	Slab	49%	***185%***
	Timber	71%	***195%***
Thredbo CZ08	Slab	N/A	***260%***
	Timber	N/A	***261%***

8.4 Reasons for the performance difference between the 2019 NCC GC and NatHERS 7-stars

In hot climates (1 to 3), one of the main reasons the 7-star detached dwellings fail the 2019 GC is the improved allowance in NCC 2022 for air movement provided by openable windows and ceiling fans. This enhanced air movement modelling allows higher heat gains to be tolerated while providing acceptable summer performance.

In the warm inland climate (4: Mildura), the 2019 stringency for winter performance requires significantly lower heat loss through glazing than is needed to obtain 7-stars. The primary reason for this appears to be that the 2019 GC overestimates the impact of windows in bedrooms on heating loads compared to NatHERS.

In mixed climates with significant heating **and** cooling (5: Perth and Sydney), the 2019 GC appears to provide a similar window performance assessment to NatHERS, i.e. 7-star dwellings generally perform significantly better than the 2019 GC requires.

In cool climates, the 2019 assessment of the summer performance is as expected for 7-star dwellings: 7-star dwellings significantly exceed minimum requirements. In winter, however, the 2019 GC requires significantly lower heat loss or higher winter heat gain through windows than a 7-star dwelling in NatHERS provides. This higher performance requirement is due to several factors:

- The overestimation of the impact of bedroom window performance on heating loads, as found in NCC Climate Zone 4.
- The new weather data (to be introduced with the update to NCC 2022) may have also played a role. Heating loads are generally slightly reduced, and cooling loads are slightly increased due to the more accurate estimate of solar radiation used in the new weather files, thus reducing the overall impact of heating,
- NatHERS allows a trade-off between winter and summer performance while the GC requires performance targets for each season,
- The 7-star rating level for Hobart and Thredbo can be achieved with fairly low levels of double glazing. This relatively modest requirement represents the policy intent of jurisdictions at the time the rating scale was developed. It could be argued that the stringency of NatHERS rating levels in these climates should be improved, however, aligning with NatHERS, not amending NatHERS, was the brief for this project.
- NatHERS considers the impact of the solar absorptance of roofs, walls and window frames while the 2019 GC does not. The use of darker colours in cooler climates can significantly improve dwelling performance (typically around 0.3 stars), so window performance can be offset against the use of more climatically appropriate colours in NatHERS. NCC 2022 does consider the impact of solar absorptance.

8.5 Impact of NCC 2022 elemental glazing provisions on compliance costs and energy savings

The Class 1 RIS costs and benefits were assessed using six dwellings on a slab and timber floor (SBH01-06 see *Costs and Benefits of Upgrading Building Fabric from 6 to 7 Stars -Tony Isaacs Consulting.pdf*). The RIS compares the average improvement costs for these dwellings with the energy savings from the dwelling with average heating and cooling energy use, called the composite dwelling in the RIS: SBH05. It is a 3 bedroom home with two living areas and a double garage. It has a Gross Floor Area of 204.8 m^2 and a Net Conditioned Floor Area of 136.2 m^2 (slightly smaller than the average from the AHD). The plan has been included in Appendix 3.

The composite house, SBH05, was used to model cost impacts. This dwelling has close to the average 2019 2022 GC target performance of all detached dwellings.

The following process is repeated in each NCC climate zone *using the 2019 GC* (including the separate figures developed for brick cavity and lower weight walls in CZ05, selected to represent typical house construction methods in two climates developed for CZ05in: Perth (for use with brick cavity walls) and Sydney:

- the window properties of the dwelling are modified till the dwelling just passes both Summer and Winter performance targets,
- the window schedule is entered into data take of spreadsheets and pasted into the cost evaluation spreadsheet,
- the cost of the 7-star compliant dwelling is compared to the cost of the 2019 GC compliant dwelling,
- to evaluate the impact on energy savings (reported in the next section):

- The AccuRate building fabric file is modified to have windows with the same performance properties as those required by the 2019 GC, and the star rating is noted,
- The dwelling is simulated using the All Day and Work Day profile, and the resultant energy loads are weighted in the same 60% (All day):40% (Work day) proportion as used for the evaluation of Whole of House Impacts in the RIS,
- The heating and cooling loads are compared to the 7-star compliant dwelling to determine the percentage change to these loads,
- The cost and energy savings differences are used to allow the heating and cooling energy demand and building fabric improvement costs to be modified for input to the Acil-Allen model.

8.6 Impact on Compliance Costs

The table below shows the cost of glazing required to meet NatHERS 7-stars minus the cost of glazing needed to obtain compliance with the current NCC 2019 Glazing Calculator. A negative value indicates that glazing which complied with the 2019 GC is more expensive than the glazing specified to meet a 7-star performance requirement.

Table 6 Difference in Glazing Compliance Costs – NatHERS 7-star minus NCC 2019 Glazing calculator

Location	Floor Type	Change in Compliance Costs for dwellings using elemental compliance in NCC 2022
Darwin CZ01	Slab	-$1,146.31
	Timber	-$1,152.11
Cairns CZ01	Slab	-$841.76
	Timber	-$1,607.68
Brisbane CZ02	Slab	-$291.85
	Timber	No change*
Longreach CZ03	Slab	-$3,229.31
	Timber	-$5,018.30
Mildura CZ04	Slab	-$4,693.57
	Timber	-$2,469.30
Sydney CZ05	Slab	No Change*
	Timber	-$1,136.97
Perth CZ05 with brick cavity walls	Slab	No change*
	Timber	No change*
Adelaide CZ05	Slab	No Change*
	Timber	No change*
Melbourne CZ06	Slab	-$5,566.34
	Timber	-$2,093.88
Canberra CZ07	Slab	-$4,025.45
	Timber	-$2,061.45
Hobart CZ07	Slab	-$3,482.33
	Timber	-$2,802.06
Thredbo CZ08	Slab	-$2,426.77
	Timber	-$5,168.22

* No change – the current 7-star windows comply, however, this implies that upgrading from NCC 2019 to 2022 elemental will be a 0 cost, not an increase.

8.7 Impact on energy savings

The table below shows the reduction in 6-star energy demand caused by the application of the more stringent 2019 GC in terms of:

- Change to the star rating
- Reduction in Heating loads, and
- Reduction in Cooling loads.

Table 7 Change to star rating, heating and cooling load of 6-star houses when glazing is installed to meet the NCC 2019 Glazing Calculator

Location	Floor Type	Change in star rating	Reduction in heating load % compared to NCC 2019 GC	Reduction in cooling load % compared to NCC 2019 GC
Darwin CZ01	Slab	0.1	0.00%	1.31%
	Timber	-0.1	0.00%	-0.96%
Cairns CZ01	Slab	0.3	0.00%	3.36%
	Timber	0.6	12.31%	5.99%
Brisbane CZ02	Slab	**0.0**	0.91%	0.74%
	Timber	**0.0**	0.00%	0.00%
Longreach CZ03	Slab	0.9	1.66%	14.13%
	Timber	0.7	8.68%	9.55%
Mildura CZ04	Slab	0.8	17.33%	14.80%
	Timber	0.1	4.60%	0.46%
Sydney CZ05	Slab	**0.0**	0.00%	0.00%
	Timber	0.1	6.05%	-4.75%
Perth CZ05 with brick cavity walls	Slab	**0.0**	0.00%	0.00%
	Timber	**0.0**	0.00%	0.00%
Adelaide CZ05	Slab	**0.0**	0.00%	0.00%
	Timber	**0.0**	0.00%	0.00%
Melbourne CZ06	Slab	1	21.04%	12.38%
	Timber	0.8	15.19%	12.38%
Canberra CZ07	Slab	0.8	13.69%	16.34%
	Timber	0.6	12.86%	6.05%
Hobart CZ07	Slab	0.6	15.39%	27.40%
	Timber	1.0	19.24%	23.94%
Thredbo CZ08	Slab	0.7	10.85%	51.74%
	Timber	1	13.87%	44.47%

8.8 Glazing changes: NCC 219 Glazing Calculator vs NatHERS 7-stars

The tables below show the change to the areas of different types of glazing to achieve compliance with 7-stars or the NCC 2019 GC. These differences in type and area of glazing lead to the cost differences shown in Table 6 above.

Table 8 Area of different types of glass required by NCC 2019 and 7-stars in various climates 1

Climate	01 Darwin				03 Longreach				10 Brisbane		24 Canberra	
Floor	Slab on Ground		Timber		Slab on Ground		Timber		Slab on Ground		Slab on Ground	
Window Poperties	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019
Area single glazed clear	27.3	0.0	3.9	5.4	33.0	0.0	16.6	5.4	31.3	25.4	25.9	1.5
Area single low e	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
Area single glazed tinted	0.0	21.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area single glazed heavy tinted	0.0	7.6	9.7	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0
Area single low e tint	0.0	0.0	13.7	21.9	0.0	31.5	14.9	13.2	0.0	0.0	0.0	0.0
Area double glazed argon fill low e	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	0.0	0.0	3.8	25.5
Total Window Area	28.2	29.7	28.2	28.2	33.0	31.5	31.5	30.0	31.3	31.3	29.7	29.1

Table 9 Area of different types of glass required by NCC 2019 and 7-stars in various climates 2

Climate	24 Canberra		26 Hobart				27 Mildura				28 West Sydney	
Floor	Timber		Slab on Ground		Timber		Slab on Ground		Timber		Timber	
Window Poperties	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019
Area single glazed clear	20.6	1.5	27.1	1.5	24.4	1.5	27.1	2.6	10.4	1.5	10.7	12.8
Area single low e	0.0	2.3	0.0	2.1	0.0	2.3	0.0	2.6	0.0	3.3	0.0	0.0
Area single glazed tinted	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
Area single glazed heavy tinted	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area single low e tint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.6	4.0
Area double glazed argon fill low e	9.6	23.7	4.4	25.5	5.8	23.7	5.9	28.2	18.2	28.2	0.0	12.5
Total Window Area	30.2	27.4	31.5	29.1	30.2	27.4	33.0	33.4	29.7	32.9	29.3	29.3

Table 10 Area of different types of glass required by NCC 2019 and 7-stars in various climates 3

Climate	32 Cairns				60 Tullamarine				69 Thredbo			
Floor	Slab on Ground		Timber		Slab on Ground		Timber		Slab on Ground		Slab on Ground	
Window Poperties	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019	7-star	NCC 2019
Area single glazed clear	22.4	0.0	27.0	5.3	29.7	0.0	19.1	2.2	29.7	0.0	19.1	2.2
Area single low e	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area single glazed tinted	9.1	21.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area single glazed heavy tinted	0.0	7.6	4.4	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area single low e tint	0.0	0.0	0.0	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area double glazed argon fill low e	0.0	0.0	0.0	0.0	0.0	29.3	11.1	24.5	0.0	29.3	11.1	24.5
Total Window Area	31.5	29.7	31.5	29.7	29.7	29.3	30.2	26.7	29.7	29.3	30.2	26.7

9 Revised costs associated with class 2 PV installations

In the CRIS analysis (section 2.4 of the NCC 2022 Update Whole-of-Home Component Report) it was assumed, based on limited data available at the time that the cost of installing PVs into a class 2 dwelling would impose on average a cost impost of 25% over and above that observed in relation to large class 1 installations.

As part of the DRIS process it was agreed that further research into this aspect was warranted. Consequently ITP Renewables undertook a limited analysis of the range of likely costs associated with the installation of PVs into class 2 dwellings. This was undertaken as a comparative cost compared to the cost associated with installations into class 1 installations (see Appendix 4 of the NCC 2022 Update Whole-of-Home Component Report). The class 2 PV cost analysis can be found in Appendix 2 – Consultant Advice Notice (ITP Renewables) at the end of this document.

The study found that the expected cost impost associated with installing PVs into class 2 dwellings (compared to class 1 dwellings) could range from -7.5% to as much as +73%. The cost impost on a particular project being highly dependent on the specific design and location of the building and the proposed PV system, particularly its system for managing output to individual lot owners.

On this basis it was decided that for modelling purposes a conservative class 2 PV cost impost of 50% rather than 25% would be applied to class 2 developments. In reality this had little impact on the modelled results because for reasons as noted in Section 12 the use of PVs was generally avoided in relation to compliance pathways for class 2 dwellings.

10 Investigated option on re-setting of benchmark equipment assumptions in Queensland

10.1 Background

In the cost benefit analysis undertaken for the CRIS a common assumption regarding the type of equipment assumed to constitute the energy performance benchmark was applied uniformly across all jurisdictions. This equipment in combination with an upgraded building shell (7 Stars) set the energy budget for Option A (100%) and Option B (70%) in the CRIS. The equipment that formed the benchmark was:

Heater: 4.5 Star (old GEMS) heat pump type ducted heater

Cooler: 4.5 Star (old GEMS) heat pump type ducted cooler

Water Heater: Gas Instantaneous Water Heater[7]

In the case of Class 2 dwellings in particular, this benchmark produces a BCR outcomes for Queensland that is less than 1.

Queensland is different to most other states in that gas water heating enjoys only a very minor share of the market in both class 1 and 2 dwellings (approximately 3%), compared to class 2 dwellings in Victoria, NSW ,

[7] Noting that in very mild climates such as found in south-east Queensland, the performance of the water heater is particularly significant because the heating and cooling loads are relatively small in comparison to locations with more severe climates.

SA and WA where the share is at least 70% in each case. Whilst availability clearly limits uptake in Queensland, the other important factor is fuel cost.

Queensland has the highest natural gas fuel price of all jurisdictions. As such, a benchmark that includes a gas water heater tends to inflate the benchmark running costs which effectively makes for a comparatively low regulatory stringency level in comparison to other jurisdictions.

Given that practically all class 2 dwellings in Queensland already incorporate heat pump heating/cooling (or no heating cooling) the use of a gas based water heater benchmark in Queensland means that in most cases little or no upgrade of equipment would be required to comply with the proposed regulations (particularly Option B). In most cases (again, particularly in the case of Option B) the only upgrade required would be in relation to the building shell which by virtue of the generally mild climate in Queensland produces very modest benefits only.

On that basis, the option of changing the water heater benchmark from gas instantaneous to heat pump for class 2 dwellings was explored.

The BCR using the new benchmark can be improved to 1.27 compared with 0.95 for the old benchmark using gas instantaneous water heater. It is worth noting that the type of hot water system installed in class 2 dwellings also depends on the type of apartments (i.e. low, medium or high rise dwellings). For example, a centralised hot water system in a common area is more likely to be installed for a high-rise complex.

See also Section 12 for further discussion regarding the use of heat pump technology in class 2 dwellings.

11 Adjustments to base case PV capacity

For the CRIS analysis, estimates were made of the propensity of base case class 1 dwellings that were fitted with PVs as well as the average capacity of those PV installations (see section 8.6 of the NCC 2022 Update Whole-of-Home Component Report). The assumed capacity of the PV installations was based on analysis undertaken by C4NET specifically for this project. That analysis covered Victoria only but was extrapolated to other jurisdictions. The C4NET analysis suggested (at least for Victoria) that the average PV installation in base case dwellings that already installed PVs was approximately 5.5 kW in 2020. On that basis, a slightly more conservative value of 5kW was agreed to be used in the CRIS analysis across all jurisdictions[8].

Subsequent to the CRIS and as part of the DRIS update, C4NET were contracted to expand their analysis to three further jurisdictions (NSW/ACT and Queensland)

Using the latest year containing a complete data set (2019) the following average PV system capacities were determined by C4NET:

- NSW/ACT ACT – 5.77 kW
- VIC – 5.43 kW
- QLD – 6.70 kW

In all cases the trend pre-2019 was upwards (increasing PV system capacity) but this trend would be expected to flatten off because 6.6 kW is generally the industry standard maximum for houses with single phase power supply. Installing more than 6.6 kW means that you start to lose some of your generation because of feed in tariff limits[9].

[8] The CRIS analysis model was only capable of modelling in 1 kW increments so a choice had to be made between a 5kW system or a 6 kW system.

[9] For those that install batteries that is not such an issue but that is a small % of dwellings at this stage.

Considering the capacities in 2019 and the likely upward trend in coming years it was agreed with the ABCB that the capacity assumptions should be varied from that adopted for the CRIS (5kW). The revised capacity assumptions were:

- QLD – 7kW
- All other jurisdictions jurisdictions – 6kW

This change had negligible impact on the benefit cost outcomes because irrespective of whether the PV installation in the base case is 5kW or 6kW or 7 kW, such a capacity is sufficient by itself to meet the proposed performance requirement (either option A or B). That is, for those dwellings in the base case that already install PVs of 5kW capacity or more, the only upgrade requirement for an average sized dwelling under the proposed regulations would be to the building fabric itself (i.e. 6 stars to 7 stars)

12 Design response limitations – Class 2

12.1 Background

The Whole of House (WoH) regulatory proposal for NCC 2022 sets a minimum performance standard that can be met by various modes of upgrade. Primarily these modes are upgrades to:

1. The thermal performance of the building fabric
2. The type and performance of any installed space conditioning equipment.
3. The type and performance of water heating equipment
4. The inclusion of on-site renewable energy supply (primarily PVs)
5. The performance of lighting equipment
6. The performance of pool pumps (where installed)

As part of the proposed regulation, Item 1 (building fabric) is already subject of an upgrade from an equivalent of 6 NatHERS stars to 7 stars. Item 5, Lighting, offers only very limited scope for upgrade in either class 1 or 2 dwellings and Item 6 only applies to dwellings that install a swimming pool and in the case of class 2 dwellings such pools are typically located in common areas and therefore not subject to the proposed WoH regulations.

This means that for most designers the main options for upgrade are limited to space conditioning, water heating and PVs (with a possibility that some might also choose to upgrade their building fabric performance above the 7 star minimum).

For class 2 dwellings however two of these options (PVs and high performance water heaters) whilst technically possible to integrate into a class 2 context present a range of practical issues that industry as a whole is yet to fully come to terms with. Having said that it should be noted that a few early adopters have taken up the challenge.

12.2 The Issue Specifics

As noted in the previous section the installation of either high performance water heaters or PVs present some practical issues for class 2 construction.

12.2.1 PVs in class 2

Issues relating to the inclusion of PVs in class 2 construction have been canvassed previously in the work undertaken for NCC 2022.

In summary the key issues are:

1. Individual systems for each apartment are generally likely to be impractical and complicated to set up, potentially only possible in very low rise developments 2 – 3 stories
2. Systems that only deliver the PV output to equipment in common areas would in most cases significantly limit the benefits associated with the installation making them not cost effective (note: many classes of common area equipment e.g. lifts and ventilation equipment are not included in the proposed NCC 2022 WoH budget).
3. Limited roof space for mounting panels (compared to class 1 dwelling), particularly in higher rise apartments where the roof area to total floor area ratio is low.
4. Flat and concrete roofs that are more common in class 2 developments will require additional equipment to ballast and tilt the solar panels
5. Allocated space for panels might preclude, or partly preclude other desirable features such as roof gardens
6. Issues of ownership of assets and potentially complicated owners corporation rules may be required to accommodate the system.
7. Long cable runs may be required plus special equipment to manage the distribution of PV output. This is basically an added cost issue only
8. Some system types can limit choice for individual Lot owners in relation to electricity retailers.

None of these issues are insurmountable and advances in PV panel design (e.g. for application to walls rather than just roofs), advances in energy sharing enabling equipment and the development of model owners corporation rules that deal with shared PV systems will all make the transition to PVs in class 2 dwellings more straight forward in the longer term.

12.2.2 Water Heaters

Water heating is a significant end use in terms of energy consumption and cost. In fact, in locations with milder climates such as Sydney and Brisbane where space conditioning demands are very low, water heating can account for the largest share of regulated energy usage.

At the lower end of the performance spectrum[10] are the more traditional technologies such as resistance electric water heaters (either continuous or controlled load) and gas water heaters (including storage and instantaneous).

In part, the benchmark water heater (Gas Instantaneous) was selected on the basis that it is commonly used in class 2 dwellings in most major jurisdictions (Qld being the notable exception) and effectively this sets a relatively modest stringency level. This means that in the case of Option B under the CRIS, compliance can generally be achieved using a "low performance" water heater in combination with a reasonably efficient heat pump heater/cooler (also common practice throughout Australia in class 2 dwellings) with no need to undertake other measures such as incorporating PVs which can present issues (see previous section).

In the case of Option A (30% more stringent than Option B) for some, the use of a high performance water heater is likely to form an important plank in the compliance pathway particularly if PVs are not practical to install. This however can present some issues in certain Class 2 context.

The main high performance water heater options are:

[10] Note: "Performance" in the context of the regulatory metric (societal cost) mainly relates to the expected running costs associated with the water heater and is therefore somewhat dependent on the tariffs in the particular jurisdiction. Whilst a gas water heater might be relatively inexpensive to operate is say Victoria, in Queensland where gas prices are significantly higher this option is less attractive.

- Heat pump
- Solar with electric boosting
- Solar with gas boosting

Water heating systems in class 2 dwellings take one of two formats, either as a single centralised system located in a plantroom that serves all units or as individual systems within each unit, serving the needs of that unit only.

Where the system is a centralised system then the various high performance options are generally practical to achieve provided that either:

1. there is adequate roof space for the solar thermal collectors e.g. on the roof of the plantroom if located on the top of the building (free roof space is less likely to be available if PVs were to also be installed) or;
2. the plant room has access to an external air source for heat pump type water heating (this is usually the case)

Where the system is an individual system then various practical issues can arise as follows:

1. Solar systems need space (generally roof space) for their collector panels to be mounted upon. Such space in class 2 dwellings is generally owned by the owner's corporation and is generally not available for individual Lot owners to use to mount their equipment upon.
2. Even if the issue noted in point 1 can be overcome, unless the apartment is on the uppermost floor, generally speaking the pipe runs between the water heater in the unit and the panels on the roof will be too long and impractical to install.
3. Heat pumps have fewer practical limitations compared to solar hot water systems but the heat pump (or at least its heat exchanger part) will need to be installed outdoors (e.g. on a balcony or in a courtyard if on the ground floor) or potentially behind an external wall facade provided there is free airflow e.g. via louvres in the facade). Mounting on a balcony obviously would take up some space (usually very limited in apartments), but this is not impractical to do[11] (provided the apartment does in fact have some form of balcony or courtyard). Use of a split system heat pump water heater would further reduce the impact on usable area on the balcony but add some additional cost (whilst split systems are generally more costly than integrated systems they are also generally more efficient). If an integrated system were mounted on the balcony this then may free up some internal space formerly used for housing an internal water heater.

12.3 Issues Summary

In summary, the key issue is that at present the upgrade options palate for class 2 developers is likely to be more limited than that available for class 1 dwellings. The use of PVs in class 2 is not as yet a well-established technology and there are somewhat less challenging issues with some aspects of installing high performance water heaters in a class 2 context, particularly to individual units.

These limitations tend to suggest that CRIS Option B might be a more practical introductory (2022) performance level for WoH regulations for class 2 dwellings. This view is now further supported by amended and expanded cost benefit analysis of class 2 dwellings.

[11] In fact it is already common practice to install the heat exchanger part (outdoor unit) of a heat pump space conditioner on an apartment's balcony or even on an external wall in some cases.

13 Thermal Bridging

Whilst the cost associated with addressing thermal bridging were included in the CRIS economic analysis the benefits in terms of reduced heating and cooling loads and consequent reduced space conditioning operational costs were not factored into the analysis undertaken by ACIL Allen.

Following feedback during the public consultation process the energy savings benefits associated with addressing thermal bridging issues (as identified in the technical analysis) were factored into the revised impact analysis by ACIL Allen. This had the effect of improving BCRs in all jurisdiction but particularly in those with harsher climates and or a higher propensity for steel framed construction.

14 Appendix 1 – Optimisation rules

Rule	Class 1	Class 2 or class 1 shaded blocks
1	Exclude option if PV requirement exceeds adopted maximum limit (7.5 kW)	Generally use of PVs in class 2 or shaded blocks is avoided in option A and always in Option B. Note: Should a zero net regulated energy requirement ever be applied in the future then the use of PVs could not be avoided.
2	Exclude any Gas equipment options unless gas is already being used for heating or hot water in the base case	Exclude any Gas equipment options unless gas is already being used for heating or hot water in the base case
3	Exclude option if improved case is central conditioning and base case is room conditioning (i.e. Assumes same level of service)	Exclude option if improved case is central conditioning and base case is room conditioning (i.e. Assumes same level of service)
4	Exclude option if improved case is room conditioning and base case is central conditioning (i.e. Assumes same level of service)	Exclude option if improved case is room conditioning and base case is central conditioning (i.e. Assumes same level of service)
5	Exclude option if improved case is other than heating only when base case is heating only (i.e. Assumes same level of service)	Exclude option if improved case is other than heating only when base case is heating only (i.e. Assumes same level of service).
6	Exclude option if improved case is other than no heating and no cooling when base case is no heating and no cooling (i.e. Assumes same level of service)	Exclude option if improved case is other than no heating and no cooling when base case is no heating and no cooling (i.e. Assumes same level of service)
7	Exclude option if improved case includes wood heating when base case does not already include wood heating (i.e. Does not permit further expansion of wood heating)	Exclude option if improved case includes wood heating when base case does not already include wood heating (i.e. Does not permit further expansion of wood heating)

Rule	Class 1	Class 2 or class 1 shaded blocks
8	Exclude option if improved case does not include a form of solar hot water heating when the base case already includes a form of solar hot water heating (i.e. Assumes solar water heater is either a preferential choice or mandated by state regulation)	Exclude option if improved case does not include a form of solar hot water heating when the base case already includes a form of solar hot water heating (i.e. Assumes solar water heater is either a preferential choice or mandated by state regulation)
9	Only allow water heater options permitted in the particular jurisdiction unless the base case happens to be an exception to the permitted options (very few cases where this happens)	Only allow water heater options permitted in the particular jurisdiction unless the base case happens to be an exception to the permitted options (very few cases where this happens).
10	Exclude option if base case includes a Heat pump water heater but the improved case does not include either a heat pump water heater or a solar water heater. Assumed that a high efficiency water heater is either mandated or preferred	Exclude option if base case includes a Heat pump water heater but the improved case does not include either a heat pump water heater or a solar water heater. Assumed that a HE water heater is either mandated or preferred
11	This rule does not apply to class 1	Exclude option if improved case does includes a form of solar hot water heating when the base does not (i.e. Cannot assume solar water heating is practical in class 2 (or shaded blocks) if it is not already in the base case)
12	Exclude option if improved case does not include both heating and cooling when the base case includes for both heating and cooling (i.e. Assumes same level of service)	Exclude option if improved case does not include both heating and cooling when the base case includes for both heating and cooling (i.e. Assumes same level of service)
13	Exclude option if improved case includes evaporative cooling when the base case does not (i.e. Assumes same level of service i.e. evaporative cooling cannot replace refrigerative cooling)	Exclude option if improved case includes evaporative cooling when the base case does not (i.e. Assumes same level of service i.e. evaporative cooling cannot replace refrigerative cooling)
14	Exclude option if improved case includes only room cooling when the base case includes Central cooling (i.e. Assumes same level of service)	Exclude option if improved case includes only room cooling when the base case includes Central cooling (i.e. Assumes same level of service)

Rule	Class 1	Class 2 or class 1 shaded blocks
15	If a resistance electric water heater is used in the base case and in the improved case, then it is assumed that the choice of either continuous or controlled tariff will remain unchanged between the two cases. The selection of a continuous tariff ("peak") type water heater over a controlled tariff ("off peak") type water heater probably related to space and capital cost considerations which are unlikely to change in the improved case. It is also assumed that in the base case, the selection of an offpeak water heater over a peak water heater would have been in cases where space is not such an issue and the lower running costs were seen as a desirable feature.	a resistance electric water heater is used in the base case and in the improved case, then it is assumed that the choice of either continuous or controlled tariff will remain unchanged between the two cases. The selection of a continuous tariff ("peak") type water heater over a controlled tariff ("off peak") type water heater probably related to space and capital cost considerations which are unlikely to change in the improved case. It is also assumed that in the base case, the selection of an offpeak water heater over a peak water heater would have been in cases where space is not such an issue and the lower running costs were seen as a desirable feature.
16	Where a Gas instantaneous water heater is used in the base case it is assumed that generally a preference therefore exists for this type of water heater and that compliance pathways other than those that include changing the water heater type will generally be adopted Note: Gas Instantaneous provides what is widely considered to be a desirable service provision whereby endless hot water can be made available to the householder if and when required).	Same rule as for class 1 except that for class 2 only an exception to this rule is allowed in respect of dwellings without heating or cooling equipment installed. In this case a wider range of water heater upgrade options are likely to be considered because there are no options available to upgrade heating equip, cooling equip or add PVs.
17	Where a gas storage water heater is used in the base case it is assumed that this would not be replaced with a resistance electric water heater (which may be marginally less expensive). This option would have already been open to the builder/owner who has a demonstrated preference for gas rather than resistance electric water heating	Where a gas storage water heater is used in the base case it is assumed that this would not be replaced with a resistance electric water heater (which may be marginally less expensive). This option would have already been open to the builder/owner who has a demonstrated preference for gas rather than resistance electric water heating

15 Appendix 2 – Consultant Advice Notice (ITP Renewables)

Project	EES Apartment (Class 2 bldg.) PV Costs	**Project Number**	22003
To	Robert Foster, Energy Efficient Strategies	**CAN No.**	22003 -1
From	Jonathan Kennedy, ITP	**Pages**	38
Date	27/01/2022		
Subject	Assessment of PV installation costs for Class 2 Buildings in Australia		

Project Background

As part of Energy Efficient Strategies' (EES) role in assisting the Australian Building Codes Board (ABCB) to develop new energy efficiency provisions for the National Construction Code 2022, EES need to assess the feasibility and cost implications associated with the fitting of PV systems to new Class 2 (apartment) buildings.

Class 2 buildings raise several issues for the installation of solar photovoltaics (PV). The two primary considerations for installing solar on Class 2 buildings are: how the energy generated by a PV array is to be used within the building; and the practical considerations of integrating a PV system into a Class 2 (apartment/flat) building. This Consultant Advice Notice (CAN) will address the issue of the practical considerations of installing PV on new Class 2 buildings in Australia and the potential additional costs associated with this relative to an equivalent installation in a Class 1 (detached residential) building.

This report only considers newly constructed Class 2 buildings and so excludes the cost implications of retrofitting a PV array to an existing Class 2 building.

Financial Implications – PV for new Class 2 Buildings

The below section briefly outlines the likely cost imposts of installing PV on Class 2 buildings at various stages of the project (e.g. planning, design, implementation).

Planning & approvals

The installation of a PV array on a Class 2 building will typically require some sort of development and building/structural approval, which can constitute a not insignificant fixed project cost for retrofit type projects where the required approvals are solely for the purpose of fitting PVs to an existing building.. However, given this CAN only considers new Class 2 buildings, it is likely that the inclusion of a PV system within the overall project development and building/structural approval costs will be negligible.

Installation costs

The specific design characteristics of a building and the proposed PV system significantly impact the cost of a PV system installed on the building. This results in a wide range of potential cost implications for the installation of PV on Class 2 buildings.

The sections below summarise the potential cost implications of installing PV on a Class 2 building.

Roof integration

Class 2 buildings typically have a flat roof, and so PV systems installed on them may be tilt mounted to optimise system production (although it is not uncommon for systems to be flush mounted on flat roofs). Tilt mounting frames incur a cost premium of ~40% compared to flush-mounted solar PV. While the same is true for the installation of PV systems on Class 1 buildings, tilt mounted systems are less common on Class 1 buildings. Where a Class 2 building has an atypical roof surface (i.e. one for which PV mounting systems are not typically designed), such as a concrete roof, there may be a further cost impost related to the interface between the mounting structure and the roof surface. One method of securing an array to a flat concrete roof, for example, is to use ballast to fix the mounting structure in place. This can add a significant cost to a project, potentially doubling the mounting system cost. For new Class 2 buildings, this cost can be mitigated through building design that either uses a roof material that is compatible with common PV mounting systems, or provides a simple or cheap method of securing the PV system to the roof.

Wind loading

The wind load rating of a structure is predominantly influenced by where in the country it is located, its altitude above the ground, and the surrounding environment. Class 2 buildings are likely to be taller than Class 1 buildings, resulting in higher wind loading on a PV system installed on the roof.

High wind loading increases the cost of a PV array as it requires additional fixings to secure the array to the building. This adds a cost to the system through the need for additional materials and the added labour required to install the array on the roof. The mounting structure and its installation typically makes up 15 – 20% of the cost of a PV system. The mounting structure and installation cost for a PV system located in a high wind loading category (such as on the roof of a Class 2 building) may cost up to 5% more than for a typical installation on a single storey roof.

This cost could be somewhat mitigated through building design such as the inclusion of parapets around the edge of the roof to reduce the wind loading for structures on the rooftop. Additionally, if a building has a roof type where the PV mounting will be fixed directly to the purlins (i.e. a metal deck type roof), a purlin spacing of less than 1200 mm will help to reduce the installation expense for a PV system in most locations within Australia.

Electrical installation

A PV system on a Class 2 building will typically require a direct electrical connection to the building's main switchboard (MSB). Depending on where the MSB is located relative to the location of the PV system, this could result in very long cable runs. Cables and their installation typically make up ~5% of the cost of a PV system. However, for very long cable runs this cost can increase significantly, up to two and a half times the typical cost if a system design requires long AC cable runs (between the PV inverter and MSB). For a newly constructed building, this additional cost can be mitigated through building design and construction through the provision of an adequately sized PV circuit from the MSB to the rooftop (or wherever the PV inverters are proposed to be installed).

The metering requirements for PV on a Class 2 building depend on how the PV is integrated into the building and tenants' electrical infrastructure. Typically, there will be no additional metering requirements as standard electrical and metering arrangements within a new Class 2 building will be capable of integrating PV systems in a behind-the-meter, or "virtual" behind-the-meter type configuration. Under some configurations, or when using proprietary demand or generation management systems (such as the Allume SolShare device), an additional hardware and/or software cost may be imposed upon the system. This fixed cost will vary depending on the nature of the hardware/software required (Allume SolShare cost is ~$12,500 per 22 kW unit excluding installation).

Under AS5033, the DC voltage for a PV system on Class 1 or Class 2 buildings cannot exceed 600V. This limits the length of PV strings, resulting in more strings of PV modules being required to achieve the desired PV array capacity on the roof. This will lead to additional DC cable runs, and DC protection for the PV array. It may also limit the use of larger, cheaper PV inverters. This requirement could have a 15 - 20% cost impost on Balance of System (BOS) material and installation costs, for larger PV systems.

Class 2 buildings are likely to have larger PV arrays installed on their roof than would be typical for Class 1 buildings. This may result in larger three phase (commercial) PV inverters being used for these systems.

Commercial PV inverters are typically 30 -50% cheaper per unit capacity than single phase residential inverters.

Class 2 buildings are likely to require additional plant or equipment (Cranes, scaffolding, etc.) to provide roof access for Solar PV installation personnel and equipment. This document only considers the installation of new build Class 2 buildings, so it is likely that this equipment will be required for general construction access to the roof. In this case, the additional cost impost for roof access to install a solar PV system during the construction of a class 2 building will be negligible.

Conclusion

Table 11 below summarises the potential cost implications of installing PV on a Class 2 building, relative to a Class 1 building, in Australia.

Table 11 Summary of cost implications of installing PV on Class 2 building in Australia

Category & Description	Additional Cost (relative to Class 1 building)
Approvals	Negligible
Wind loading	Up to 5% additional cost for mounting structure and install cost (which constitutes 15-20 % of project costs) - depending on the site
MSB cabling	Up to 250% additional cost for cabling materials and installation (which typically makes up ~5% of project cost) for long or difficult cable runs
Metering / Control	Additional metering cost for PV on Class 2 buildings could be negligible. But under some electrical configurations additional hardware may be required. The Allume SolShare device is taken as an upper estimate of this potential with a material cost of at least $0.57 / W (380% of BOS cost) and an additional installation costs (assumed as 5% of overall installation cost).
600V limit	15% - 20% additional cost for BOS material and installation, for larger (50 -100 kWp) PV arrays.
Inverter	30% -50% cheaper inverter ($ per Watt) cost

Table 12 below presents a typical high level cost breakdown for the different rooftop PV system components and outlines the potential impacts of the various items outlined in Table 11 on the overall system cost.

Table 12 High level cost estimates for rooftop PV and potential cost impost for Class 2 building

System Component	Typical $/W for Class 1 rooftop PV in Australia[12]	% Of Project Cost	Potential cost impost for PV installation on Class 2 building
PV Modules	$0.50 - $0.80	35% – 45%	NA
Inverters	$0.15 – $0.25	10% - 15%	0% to -50%
Mounting	$0.10 - $0.20[13]	7.5% – 12.5%	0% to 5%

[12] Excl. installer mark-up and GST

[13] $0.20 / W cost for Class 1 building takes in to account the potential additional cost of tilt mounting on Class 1 or Class 2.

System Component	Typical $/W for Class 1 rooftop PV in Australia[12]	% Of Project Cost	Potential cost impost for PV installation on Class 2 building
BOS (Cabling, protection, metering etc.)	$0.10 - $0.15	7.5% - 10%	0% to 650%
Installation	$0.30 - $0.60	25% – 30%	0% to 24%
Total	**$1.15 - $2.00**		**-7.5% to 72.8%**

Table 12 demonstrates the potential cost impost associated with the installation PV on a new class 2 building when compared to a Class 1 building. However, the extent to which these costs are imposed upon a particular project is highly dependent on the specific design and location of the building and proposed PV system. What is however demonstrated above is the possibility of mitigating these potential cost imposts through building design and installation approaches.

16 Appendix 3 – House SBH04 used for evaluation of the impacts of Outdoor Living Area on upgrade costs

SBH04 Medium Detached

View from Street

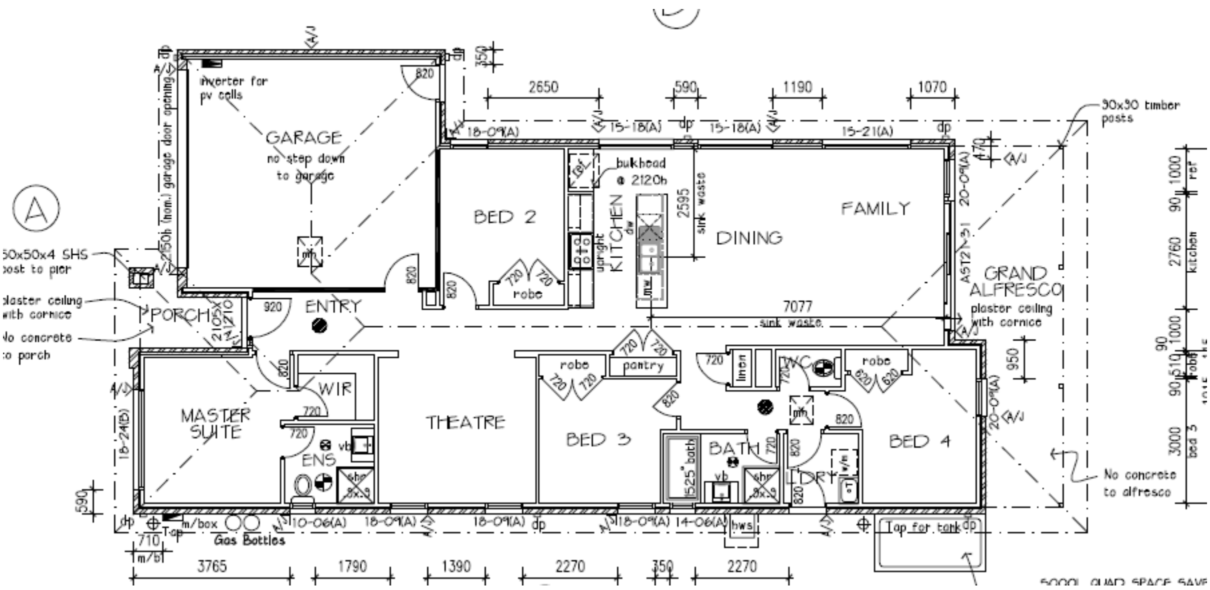
Single storey residence. Consisting of Master bedroom with ensuite and WIR, Bed 2, 3 and 4, Bath, laundry, WC, 2 circulation areas, Kitchen/living/family area, home theatre and double garage.

External alfresco area

Net Floor area 188.40 m^2. Conditioned floor area of 122.9 m^2

Source: Henley Homes

Floor Plan



SBH05 Medium Detached house

The plans and specifications for this indicative house design and used in these case studies, have been kindly provided to ABCB by the Housing Industry Association (HIA) to assist with the consultation process on the draft NCC 2022 changes.

Source: Housing Industry Association

Floor Plan