Delivery and Evaluation of the New Homes Energy Advisory Service Draft Report
&
Preliminary Consideration and Response to the National Construction Code Scoping Study

Daniel Pleiter - SECCCA Projects Coordinator
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Executive Summary

This report details the outcomes of the New Homes Energy Advisory Service (NHEAS) delivered by the South East Councils Climate Change Alliance (SECCCA) with funding from the Victorian Government. It also considers the implications of these outcomes and makes recommendations in the context of the policy options outlined in the National Construction Code (NCC) Scoping Study.

The NHEAS delivered over two years numerous free building plan consultations to home buyers at the planning stage of building a new house in the City of Casey and Cardinia Shire growth corridor, south east of Melbourne. The consultations took approximately an hour and a half and encouraged participants to take up energy efficiency measures beyond the minimum requirements. From those who participated and went on to build their homes a number of case studies were developed that give insight into the energy performance of these new home.

The project also identified that the greatest barriers to increasing energy efficiency in new homes is:

1. the lack of verification of the minimum 6 Star requirement under the National Construction Code (NCC); and
2. the lack of voluntary uptake of additional initiatives that significantly improve energy efficiency and achieve net zero carbon. This is despite technology availability, affordability and comfort and health benefits.

The majority of volume builders take a compliance only approach to building homes to meet the minimum NatHERS 6 Star requirement. Home purchasers, on the other hand, lack the knowledge and opportunity to make educated decisions on what is in their best interests from an affordability, comfort and health perspective.

The NHEAS has demonstrated that despite the attractive paybacks and improved comfort that can be achieved with energy efficiency improvements, few builders or purchasers are interested in voluntarily implementing these improvements at the construction stage. However, those that did include energy efficiency improvement enjoy the benefits of living in a comfortable home with low or zero operating costs and carbon emissions. These examples formed case studies on which the benefits, costs and implications could be closely considered.

The further benefit of the NHEAS case studies developed through the project demonstrate the real-world environment, rather than a reliance on predictive modelling that can be complex and not represent real-world outcomes. The case studies also showed that there were several quality and energy efficiency control issues that occurred in many new homes, such as missing or misplaced insulation and poor draught sealing. These issues can be resolved by ensuring that all energy efficiency works are checked on-site, verified and certified at hand over.

Builders and purchasers that participated in the SECCCA program all reported significant benefits from improving energy efficiency. Builders reported how easy it was to adjust their building practices to build high performing net zero carbon homes. Occupants reported how comfortable their homes were and the savings they were making from paying a small energy bill or not having to pay a power bill at all.

As a result, the NHEAS can now recommend the minimum regulatory requirements over and above the minimum NCC 6 Star NatHERS standard to ensure all houses into the future are certified, affordable, comfortable and net zero carbon. These key recommendations for all new homes include:

1. Installation of an appropriately sized solar system
2. Double glazing 12mm (argon filled) of all windows
3. Increase of insulation in walls across all climate zones to R2.5 in walls and R5 in roofs
4. Evaporative cooling and gas ducted heating be banned from all new homes and replaced with other fully electric alternatives that are not reliant on gas and do not breach the airtightness of the building envelope to operate
5. A shading strategy completed for all windows to ensure appropriate windows can block out the sun (e.g. eves, awnings, block out blinds, roller shutters, pergolas, etc.)
6. Installation of an electric boosted solar hot water service or heat pump (i.e. not an option to opt for a water tank instead)
7. Airtightness testing on all new homes with a minimum level of 6 ACH @50Pa required
8. Onsite ‘as built’ assessments and ratings of all new homes, such as through the Victorian Residential Efficiency Scorecard with two additional insulation and draught sealing checks

The estimated costs to achieve the above recommendations were approximately $20,000 per house with attractive paybacks of between 5 and 10 years (assuming $2500 annual energy bills). If (as observed in some households) these costs are included in the construction budget rather than additional costs, then paybacks are instant.

The NHEAS is operating until early 2020 and further case studies will be added, and an evaluation report and recommendations finalised.

1. Delivery and Evaluation of the New Homes Energy Advisory Service Draft Report

A. Introduction

The New Homes Energy Advisory Service (NHEAS) is delivered by the South East Councils Climate Change Alliance (SECCCA) and is funded by the Victorian Government. The project helps new home buyers in Victoria's largest growth corridor by providing expert advice on how to improve energy efficiency. The project operates at two display locations in partnership with Villawood and Parklea sales displays.

NHEAS provides in depth and tailored energy advice based on new home building plans to find the balance between improving energy efficiency and installing renewable energy and in accordance with budgets and household needs.

During consultations with home buyers, SECCCA reviews building plans and discusses all the available options to improve energy efficiency and those with the greatest benefit. Participants are provided with a toolkit with all the critical information to ask their builder and a cost estimator to make decisions on what to do. SECCCA provides further support through the process, providing as much advice as needed along the way to participants building their new home.

The aims of the program were outlined in the original funding application. The following is an abstract from the application:

"The CSIRO and Sustainability Victoria have both conducted studies and found that many new houses, despite the 6-star energy rating, are not performing at 6 stars. This is largely due to a lack of building air tightness. While the building regulation states the requirement for draft sealing specifications it does not regulate the level or mandatory testing of house performance. For more information see CSIRO Report: *http://www.nathers.gov.au/sites/prod.nathers.gov.au/files/files/pdf/research/House%20Energy%20Efficiency%20Inspections%20Project.pdf*

With the exception of a few builders, this performance gap is not being met. Some local governments have created tighter Environmentally Sustainable Development (ESD) controls to address this need however there are currently no additional ESD planning requirements within greenfield developments. There is clearly an opportunity to tighten residential building performance of new homes coupled with best practice advice on a range of other design considerations and renewable energy.

The service will demonstrate to decision makers, the building industry and new home buyers that the capital upfront costs are small and will significantly lower energy bills. Furthermore, the improvements required for draft sealing at construction are simple to achieve and create a marketing opportunity to attract business. This project aims to create market acceptance of best practice approaches to improving building performance in new homes.

Many homeowners struggle with the capital costs of adding renewable energy systems and energy efficient upgrade onto existing homes. By incorporating these initiatives at the time of development costs are reduced and they can be incorporated into the home's value and funded through its mortgage. The technology to be deployed for this project is available, energy efficiency measures and solar electricity is well established. *This project will promote these opportunities and increase their uptake in new residential developments. "*

The following report is a preliminary draft. It includes evaluation of program delivery, objectives to date, case studies, conclusions and recommendations. These recommendations include a reflection on the NCC Scoping Study Options open for consultation. SECCCA has numerous case studies under development and final reporting, conclusions and recommendations will be made in early 2020.

Please note that this report primarily deals with detached residential dwellings typically found in the growth corridors surrounding Melbourne. This dwelling type is expected to make up the majority of new housing stock sold through the volume home market over the next 30 years, doubling the current housing stock.

B. Visitor numbers and consultation conversion rates

To engage new home buyers SECCCA partnered with two property developers, Parklea and Villawood. As part of the partnership SECCCA Energy Engagement Officers were situated in the land sales offices and directly engaged visitors attending the display village. The following details the level of engagement achieved and how this converted into consultations and case studies.

Table 1. NHEAS Visitor numbers

The total number of visitors to the service across both locations over the last two years.

Groups	Individuals	Consultations	Case Studies
407	916	126	7

Conversion rates to participate in in-depth consultation
Of the 407 groups engaged, 126 consultations greater than 10 minutes were held, representing a conversion rate of over 20%. Approximately 50 were reported to have undertook a further detailed consultation, however only 16 completed feedback forms. Of these groups:

- seven are participating in case studies (and a further seven are now under development since this last milestone report)
- nine requested a call back once they are closer to commencing construction

The remainder were contacted or attempted to be contacted and now are marked as completed for the following reasons:

- Could not be contacted
- Were no longer interested or plans had changed
- Had sold their land or did not settle
- Other unspecified reasons

Conversion rates for implementation of solutions covered in the in-depth consultations
Only the seven that are participating in the case studies can be evaluated on conversion rates for implementation of solutions (to building more energy efficient homes). Results indicate that case study participants implemented 7 key actions out of a possible 10 on average. This represents a very good result

and as the case studies below indicate has provided rich data to understand the cost and energy implications.

Builder and Developer Conversion Rates

Engaging builders to participate in the program has been challenging. However, there have been successes and conversions in how builders and developers sell their land and houses:

SJD Homes

SJD Homes, a local builder was willing to participate in the NHEAS program and promote the service to their clients. As a result, SECCCA identified an opportunity to expand the program with funding support from Sustainability Victoria and the CRC for Low Carbon Living. This aspect of the program grew into an opportunity to build a sales display and a net zero carbon home.

The display house forms one of the case studies and has all the recommended energy efficiency features used in the NHEAS. The net zero carbon house was launched in October 2018 with the Hon. Lily D'Ambrosio in attendance. As of the 1 March 2019, they have 10 net zero emission homes under construction with many more planned.

SJD Homes also received widespread media coverage for their achievements and won the Casey Cardinia Business of the Year.

A Home of the Future Article – https://pakenham.starcommunity.com.au/news/2018-10-03/home-of-the-future-open/

Builder Nails It – Casey Cardinia Business of the Year - https://issuu.com/starnewsgroup/docs/2018-10-31_pg_28

Despite this apparent success it has been difficult for SJD Homes to convince purchasers to spend an extra $5000-$10,000 (this figure is subsided by SJD Homes by a least a further $5000) to achieve a net zero energy home. Whilst 10 homes to date are under construction, SJD Homes sell approximately 30 homes a month. This is also in spite of in-house staff training to promote the benefits to clients to uptake the offer as an upgrade.

As a result, SJD Homes are now offering the zero-emission homes as standard in all their homes. It is now an opt out requirement. The case study and questionnaire with the SJD Homes offers interesting observations about the ease at which SJD Homes were able to embrace building net zero carbon homes. See Case Study 5 Appendix 5 for more information.

Parklea

Parklea, a land developer, were also integral in supporting the building of the net zero carbon home by providing the land to SJD Homes right next to an existing display home. They were able to streamline this purchase to ensure that the home was built within the time frames of the project.

Parklea embraced the need and opportunity of building net zero carbon homes through participation in the program. They have now built a new net zero carbon home for a land sales office at Kaduna Park. SECCCA will use this home as a base for its program once it opens. For more information visit www.parkleadevelopments.com.au

Villawood and South East Water

Whist SECCCA has found it difficult to recruit participants in the program at Aquarevo due to delays in land settling as a result of unforeseen additional earthworks and drainage requirements, we have participated in two builders' expos to date. At these expos SECCCA set up a stall to engage directly with potential purchasers of land in the development and those that have already bought and are looking for a builder.

South East Water have recently built an 8 Star Eco-House near the current land sales office to demonstrate the innovative water and energy features of Aquarevo and this will form one of the future case studies.

Please see details at https://villawoodproperties.com.au/community/aquarevo/

C. Case Studies Analysis

Participants in the NHEAS underwent the below process and as a result made changes according to their budgets and support from their builders:

1. Consulted with SECCCA where a detailed discussion occurred based on a review of their building plans and following the SECCCA toolkit (available on request).
2. Discussed with the builder in-person, over the phone or via email the changes they would like and received quotes for consideration.
3. On occasions SECCCA would meet again with the home buyer or their builder to discuss changes
4. Final decisions were made by the home buyer and entered into the contract.

The Case Study information was gathered through the following:

1. NatTHERS assessment.
2. Victorian Residential Efficiency Scorecard assessment.
3. Blower door test for air tightness.
4. Questionnaire with the householder.
5. Review of building plans.

Table 2 below provides a summary of the outcomes of the case studies. Please note the following:

- The costs are additional to what would have been specified as standard by the builder to meet the 6 Star minimum standard.
- The costs, bill information, comments and feedback are self-reported by the participants. Actual bill information or contracts were not collected or analysed.

For further detailed analysis of each case study refer to www.seccca.org.au or are available on request.

Table 2 Summary of Case Study Results

Case Study Number	NatHERS Rating	RES Rating	Hot Weather Rating	Air Tightness Test	Key Upgrade Points	Gas or Fully Electric	Extra Cost	Double Glaze cost component	Orientation / passive solar	Solar	House size (squares)	Bills (quarter on average)
1	6.1	10	1	6.7	7	Gas / Elec	$11,200	$3000	Poor	Yes	29	Elec $0 Gas $200
2	6.8	10	2	TBC	7	Electric	$21,300	$14,000	Poor	Yes	28	Elec $0 Gas $200
3	6.0	7	1	7.7	3	Gas / Elec	$4500	$0	Poor	No	12	Elec $300 Gas $100
4	6.0	10	2	5.3	5	Gas / Elec	$6800	$0	Poor	Yes	25	Elec $ 0 Gas $135
5	7.3	10	2	3.6	10	Electric	$20,950***1*2**	$5500***2**	Very Good	Yes	27	Elec $0 Gas $0
6	6.9	9	2	4.1	10	Electric	$22,000***1**	$10,000	Good	Yes	33	Elec $50 Gas $0
7	6.0	10	2	Test A 8.0 Test B 7.8	5.5	Gas / Elec	$8,000	NA	Good	Yes	35	Elec $0 Gas $65
Average	**6.4**	**9.4**	**1.7**	**5.8**	**7**	**NA**	**$13,535**	**$8100**	**NA**	**NA**	**27**	**NA**

*1 Cost excludes $10,000 for battery (this was removed so an equal comparison could be made)

*2 Double glazing was included in the package. However, to enable a cost comparison $4000 was assumed for an upgrade from A&L Windows for all windows plus $1500 for sliding doors (based on costs from other houses)

D. Preliminary Observations and Conclusions:

Upgrades impact on power bills

1. Those that invested in solar PV resulted in significantly reduced power bills. The majority recorded very low or zero bills.
2. The clients for case study 3 intend to invest in solar however had not yet installed and were still paying a power bill of $300 on average every quarter. If this home added solar, they too would likely record a low to no electricity bill.
3. Houses in case studies 1, 3 and 4 did not invest in a fully electric house and spent on average approximately $145 on gas bills every quarter.
4. Despite the considerable expense of double glazing for the houses in case studies 2 and 6, the power bills were comparative to other homes. However, it is likely to have improved comfort.

Upgrades impact on ratings

1. Solar resulted in the biggest star increase from the Victorian Residential Efficiency Scorecard (VRES) rating by 3-4 Stars, with 10 Stars representing net zero carbon.
2. Solar did not impact the NatHERS rating. This is understandable as it is not a whole-of-house tool so does not consider appliances or renewable energy.
3. Despite many households achieving zero carbon and making a considerable number of additional upgrades few homes resulted in a 1 Star NatHERS increase, with the average increase 0.4 stars. House 5 had very good orientation and ideal living spaces with northern windows result in a 1.3 Star rating increase.
4. Despite the considerable expense of double glazing for the houses in case studies 2 and 6, the ratings were comparative to other homes.
5. Houses in case studies 1 and 4, despite the use of gas, still resulted in a 10 out of 10 VRES assessment. This equates to being carbon neutral, meaning the additional solar generated and fed into the grid offset the gas used in the home.

Upgrades impact on comfort

1. Clients that did not invest in double glazing or improved airtightness reported that the house was draughty or hot and cold at times during summer and winter (See case study 3 and 4, Appendix 5). This was reflected in the hot weather rating.
2. All participants who installed double glazing were pleased with the additional comfort of significantly reduced outside noise levels as opposed to single glazing.
3. Clients that paid extra attention to the airtightness resulted in a reported improvement in comfort levels (see case study 5 and 6, Appendix 5).
4. Clients that did not install a revere cycle split system and opted for an evaporative cooler reported that they worked poorly during hot weather above 35 degrees celsius.

Upgrades Impact on Cost

1. The costs to achieve upgrades above the NatHERS 6 Star standard varied from $7,000 to $22,000. Including an additional $4000 to achieve the minimum 6 Star standard this equates to between $13,000-$26,000 (including solar). Assuming a cost of energy bills of $2,500 per annum (see Appendix 2) this results in a payback of 5.2 – 10.4 years.

2. On a home worth $700,000 (including land) in one of Melbourne's growth corridors this represents 1-3% of overall costs.
3. Clients reported that with planning they were able to offset these additional costs by excluding other upgrades available to them, such as upgrading house sizes, tiling options, bathroom options, square set plaster corners etc. In these cases, the clients were able to stay within their baseline budget. The energy cost savings could then be viewed as returning a profit immediately.
4. This is an important distinction as it indicates that net zero carbon homes do not have to come at additional cost if included in the overall budget for a home. If regulations are put in place to mandate net zero carbon homes the prices of homes may not necessarily increase, rather other household additional extras or "luxuries" may be done without. While affordability of these initiatives is an important consideration, they should not be a barrier to achieving a net zero carbon home.

Verification of upgrades and performance

1. Clients were unable to verify the energy efficiency claims made by their builders after their homes were built. However, through the NHEAS they were, with all clients pleased with the insights and understanding of the performance of their home through on-site verification and certification processes.
2. Most homes had issues with the quality of the insulation installation, for example insulation was missing, not cut to correct sizes, uplifted or overlapping rafters. (See Appendix 5).
3. Generally, homes were adequately airtight. (Airtightness Reports are available on request)
4. Most builders did not support clients to make energy efficiency upgrades. Builders that did provide support required training, building assistance and use verification processes to ensure upgrades were delivered to meet adequate performance goals.

Preliminary conclusions NHEAS program

1. The results of the project to date demonstrate that it is difficult to engage with new home buyers on improving energy efficiency in their new home. Of the 900 individuals and 400 groups that were engaged, 126 had a minimum of a 10-30 minute consultation. Of these 50 had a further detailed consultation involving their building plans of which 16 completed feedback forms and 7 case studies completed.
2. As a result, it can be concluded that for the most part neither the client or builder will voluntarily choose to improve the efficiency of their homes over and above the minimum standards.
3. This is for a variety of reasons which may include:
    a. Purchasers focused on the essentials of securing a land and house.
    b. Purchasers not interested.
    c. Purchasers not understanding the value of energy efficiency.
    d. The difficulty to communicate the benefits of energy efficiency in a short period of time.
    e. Lack of willingness of builders to advocate for improved energy efficiency to clients.
    f. The perceived expensive costs to achieve higher energy efficiency.

Preliminary Upgrade Conclusions

As a result of the 7 case studies to date, the following conclusions can be made:

1. Solar PV is the single most cost and energy effective upgrade for new homes.
2. Whilst all houses did something a little different, there were correlations that could be drawn from the small sample size to date.

3. The house in case study 1 demonstrated a good example of a net zero carbon house that achieved a VRES 10 star rating while remaining connected to gas. A high efficiency gas heater and an electric split system were installed, spending an additional $11,200.
4. Houses in case studies 2, 5 and 6 demonstrated a good example of zero carbon homes that also achieved a VRES 9-10 star rating and were fully electric.
5. The outcomes of the case studies highlight the importance of:
    a. Understanding performance goals during the planning stage before making decisions.
    b. The sum of the many different parts makes up the whole to achieve a high-performance energy efficient home.
    c. Expensive double glazing can impact on the comfort and energy efficiency of a home however has a diminishing return on investment. More affordable 12mm argon filled double glazed windows (Case studies 1 and 5, see Appendix 5) are rated at approximately R0.3 and cost between $4,000 and $5,000. However, more expensive 18mm uPVC argon filled double glazing windows (Case study 2 and 6, see Appendix 5) rated at approximately R0.5 (See Appendix 1 for details) cost between $10,000 and $14,000. The investment from an energy efficiency perspective is poor. These funds would have been better invested in solar or a battery system.
6. Verification of upgrades is critical to ensure homes perform as required and customers are receiving what they paid for.

Preliminary Recommendations (in addition to NatHERS 6 Star standard)

Note: these recommendations are in draft form and do not represent the views any individual SECCCA member council. They are views created by the project team in the context of aiming to achieve net zero carbon homes across the volume home housing sector in Victoria.

If the performance goals are to achieve:

- Verified and certified;
- Comfortable (homes adapted to current and future extreme weather);
- Affordable; and
- Net zero carbon.

The following are the recommended mandatory requirements to the building code for all new homes:

1. Installation of an appropriately sized solar system;
2. 12mm double glazing (argon filled) of all windows and glass doors;
3. Increase of insulation in walls across all climate zones to R2.5 and in roofs to R5.0;
4. Evaporative cooling and gas ducted heating be banned and replaced by refrigerated reverse cycle heating and cooling or electric hydronic heating or similar energy efficient heating mechanism;
5. A shading strategy completed for all windows to ensure east and west windows can be blocked out from the sun (e.g. eves, awnings, block out blinds, roller shutters, pergolas, etc.);
6. Installation of an electric boosted solar hot water service or heat pump hot water service (i.e. not an option to opt for a water tank instead under NatHERS). Gas hot water heating to be phased out due to the ability of Solar PV to directly boost hot water heating during the day;
7. Airtightness testing via a blower door test on all new homes with a minimum level of <6 ACH@50Pa; and
8. Whole-of-house Victorian Residential Efficiency Scorecard assessments or similar and ratings of all new homes.

These 8 recommendations will ensure all future house are:

1. Built/installed as per specifications so customers are getting what they paid for through a verification and certification process;
2. Comfortable – particularly during the extreme weather events increasing with climate change;
3. Affordable with short paybacks – additional costs at approximately $7,000-$22,000 per house of 5.2 – 10.4 years. Assuming the solar PV system lasts 15 years during this time the household will save a further $17,500 after paybacks. See Appendix 2 for electricity cost calculations; and
4. Net zero or close to net zero carbon with minimal energy bills.

2. Further considerations in the context of the NCC Scoping Study Options

A. Introduction

The above section represents the outcomes of the work and case studies developed under the New Homes Energy Advisory Service. This provides the context in which SECCCA is providing advice to the ABCB National Construction Code (NCC) Scoping Study.

In preparation for a response to the NCC Scoping Study SECCCA consulted with three builders, ranging in size builder from 30 homes a month to 100 homes a month. SECCCA presented the builders the findings of the NHEAS and the cases studies as well as the NCC Scoping Study Options. The main discussions and concerns expressed by builders centred around:

1. Airtightness
2. Air quality
3. Affordability
4. On-site whole-of-house verification including blower door testing
5. Ways of working implications
6. Creating a level playing field
7. The best interests of consumers

As a result, SECCCA has reviewed its own findings and considered the views and concerns of builders to form the following discussions, conclusions and recommendations.

B. Window frames and glazing specification

SECCCA's recommendations do not specify a type of window frame or double glazing beyond a minimum standard of 12mm with an argon filling. The majority of windows with this specification are affordable and will result in an R value improvement from 0.1 to 0.3, a tripling of energy efficiency compared to single glazing. The case studies show that the additional costs to further improve efficiency by improvements in frames and other specifications such as low-e, uPVC or 20mm were cost prohibitive.

Conclusion outcome: Mandatory requirement of all windows to 12mm Argon filled double glazing.

C. Passive House

While a worthy aspiration, a passive house (requires no or low heating and cooling requirements) is cost prohibitive. Solar PV is a more cost-effective option by essentially trading of inefficiencies that are costly to resolve. By accepting a level of energy inefficiency this is then supplemented by generating additional energy through the solar PV system.

Achieving an airtight home less than 1ACH@50Pa under passive house standards can require a mechanical air heat recovery ventilation system to be installed plus additional insulation, an airtight membrane, double studded walls and window upgrades. Examples of these homes can add well over $50,000 of extra costs. If these goals are aspirational for home buyers they can be achieved, however in terms of regulating as minimum standard this is not recommended. As per below, an improvement of air tightness is recommended however only using conventional draught sealing methods and the plaster as the air barrier.

Conclusion outcome: Passive homes to be non-mandatory.

D. Thermal bridging interventions

Whilst thermal bridging through the building and window frames is an issue by devaluing the insulation properties of a home, rectification of these issues is costly. This inefficiency should be accepted and offset with other opportunities.

Conclusion outcome: Thermal bridging treatments to be non-mandatory.

E. Thermal mass

Thermal mass also is effective at storing heat inside the home however again can be a costly exercise if homes do not have ideal orientation. This inefficiency should be accepted and offset with other opportunities.

Conclusion outcome: Thermal mass options to be non-mandatory.

F. Gas

Space and water heating equate to around 60% of the energy used in the home. A solar PV system that generates 5,000-10,000 kWh per year can directly power or offset the energy required for heating. If a home still uses gas to run 60% of its energy needs, then the value of the solar PV is reduced and will take longer to realise the payback. The more energy is used directly from the PV solar system the shorter the paybacks.

As batteries become more affordable and are installed it makes better financial sense to heat the home and water with electricity stored in batteries at night or directly from solar during the day. Every home that has gas space and water heating also reduces the payback period and value of batteries. It is likely that these homes will have to undergo a costly appliance retrofit in a number of years to take advantage of reducing battery costs.

By providing a gas service and installing gas appliances it is locking in direct carbon emissions potentially for the life span of the home, or at the very least the appliances life span which could be over 10 years. Homes need to be future proofed and removing gas as an energy source is an obvious first step.

Gas prices are also volatile and can go up and down. As gas reserves deplete and gas is found in harder to reach places prices will continue to rise. It also raises possible health concern issues if homes are to be draught sealed tighter. Emissions from the gas can stay in the home or if the gas leaks occur the gas can't escape and can cause health related issues to occupants.

Conclusion outcome: Ban gas for all new homes from 2022.

G. Airtightness and a move to 7 Stars

Improving the airtightness and setting a standard requiring a heat recovery ventilation system and verification has been the most difficult issue to work through in the project. The main issue is that as soon as some sort of air tightness target is set, be it 10, 6 or lower, a house can be tightened too much which results in potential air quality and condensation issues. Or it's not tightened enough which affects energy efficiency. The only way to check this is through a blower door test. So, as a pathway is set of specifying air tightness such as in the current 2019 NCC requirements then a blower door test is required to verify the outcome, it should not be optional.

Improving air tightness in the literature appears to be the most effective means of reducing energy use and this makes sense as 40-50% of energy use is on space heating or cooling. Therefore, setting a realistic and effective air tightness target that balances the cost to achieve it is important. SECCCA has arrived at <6ACH@50Pa as the minimum requirement as it's not difficult to achieve however has significant return on investment. It achieves 0.3 natural air exchanges per hour and can cost as little as $500 to achieve.

A builder who conducted extensive blower tests on 100 of their newly built homes found on average their homes were achieving 5ACH@50Pa with attention to draught sealing on every job. However, there were some tighter and some not so tight. Working with builders on a few of the case studies on air tightness they reported it as very easy to ensure more attention was paid to draught sealing with only a few extra hours of work and materials valued at $500. These case study homes resulted in between 3-6 ACH@50Pa.

If homes were found to be too leaky, through the blower door test (at a cost of $500) this could be identified and rectified through the identification of where the leaks were.

To avoid any health-related issues and condensation issues from achieving a minimum of 6 ACH@50Pa or going too tight through the draught sealing process it is recommended a mechanical heat recovery ventilation (mechanical HRV) system be installed. There are a number of proponents that think this is unnecessary. However, the last outcome from setting an air tightness target at any level is to create an unknown public health risk, where years down the track untested homes are making people sick because they have been overtightened.

The only way to avoid this is through an independent onsite verification and certification process and a mechanical HRV system. At a minimum this would include a centralised system for all main living areas coupled with an air transfer kit to bedrooms or a more expensive decentralised system.

There are proponents who recommended homes that achieve an airtightness of at least 5-6 air changes per hour when tested at 50Pa justifies an investment in a quality mechanical HRV unit. Homes with this level of air tightness make it possible for these units to work optimally.

As part of the NCC changes in 2022, it is recommended that a new set of guidelines are developed to provide builders clear direction on effective draught sealing techniques to reach the <6 ACH@50Pa. SECCCA is able to provide this advice on request. As each home could be sealed tighter there is no risk to the occupants as a mechanical HRV system would be installed.

The NCC Scoping Study recommends an increase in the star rating to 7 Stars, primarily based on increasing comfort. As a first step what will significantly improve the comfort and health of occupants in new homes is improving air tightness and mechanically ventilating the home with fresh air to remove any volatile organic compounds, odours and stale air.

Increasing to the proposed 7 Stars and setting the air tightness level to 10 ACH@50Pa, as it is now in the 2019 NCC (with a non-mandatory test), is concerning as significant additional investments are being made in improving the building shell however the shell is still relatively leaky at 10 ACH@50Pa. Enough air is lost at this level and therefore does not require a mechanical HRV system.

The inclusion of these standards in the new 2019 NCC that 10 ACH@50Pa does not require a mechanical HRV system indicates that homes will not be airtight enough. Therefore the opportunity to save energy on reducing heating and cooling loads is lost. This is regardless of what gains could be made from a future increase to a 7 Star standard. Additional insulation or glazing to improve the building shell to achieve 7 Star is ineffective if homes are still leaky. Insulation, double lazing and air tightness must work together to effectively reduce household heating and cooling loads. Therefore, air tightness and verification of air tightness should be considered first before lifting the Star rating or a least in concert, subject to affordability.

Homes become comfortable when they are airtight. However, once you pay attention and improve air tightness adequately, ventilation is required to avoid the complications of an airtight home. The general principle then applies to all climate conditions, that when a home is able to control its indoor air space it then becomes energy efficient and this is what keeps the energy costs down for space heating and cooling.

In saying this, a balance needs to be made between going too airtight as cost quickly blow out when trying to aim for a passive house outcome, as illustrated in the tables below.

Table 3 Balance between an airtight home and cost

Performance Goal Airtightness (Air exchange per hour @ 50Pa of pressure)	Natural air exchange	Requirement (assumes all other 6 Star Plus requirements are meet	Performance Outcome …the lived experience	Heat Recovery Ventilation Requirement See Appendix 4 for examples	Capital Cost	Energy Running costs
<3.5	0.03-0.18	Additional membrane rap and double stud walls or uses ridged insulation products $40,000+	Maintains steady air temp, with little to no heating / cooling	Decentralised system $10,000+	Very Expensive $50,000 +	Low
3.5 – 7	0.18-0.35	Extra attention to draught sealing	Heater may go on for ½ an hour and heat remains in the room/house for 2-4 hours. Airconditioning only required on 35 degree plus days	Centralised mechanical HRV system $2500 with air transfer kit to provide fresh air to bedrooms $1500 Or a further option is a decentralised mechanical HRV system $10,000	Affordable $500 draught sealing $500 blower door test Mechanical HRV starting from $4,000	Low
7-20	0.35-1	Little attention to draught sealing	Hourly heating / cooling required	NA – uses gaps in house as the ventilation system	Zero $0	Very High

Table 4 Comparable current and alternate heating, cooling and ventilation systems

The following table demonstrates that the alternate heating / cooling options and mechanical HRV options (see Appendix 4 for examples) are comparable to the use of existing heating and cooling methods.

Current technology used in most volume homes in Victoria	**Cost**	**New requirement**	**New Technology (see Appendix 4)**	**Cost**
Evaporative Cooler	$5,000	Fully electric home	2 x Reverse Cycle Splits to main living areas	$3,000
Gas Ducted heating	$2,000	6 ACH@50Pa	2 x Centralised mechanical HRV main living areas	$2500
		Mechanical Heat Recovery Ventilation (HRV) system	Air transfer kit to bedrooms (up to 4 rooms)	$1,500
TOTAL	$7,000			$7,000
OTHER OPTIONS for larger houses 30 square plus				
Fully Ducted refrigerated cooling and heating with gas fitted heating unit	$20,000 - $25,000		Decentralised mechanical HRV system	$10,000 - $15,000
			2 X Single Splits to living areas	$6,000
			Multi-splits to bedrooms	$6,000
TOTAL	$20,000 - $25,000			$22,000 - $28,000

Conclusions outcomes:

- **Mandate a minimum standard of 6ACH@50Pa for all new homes.**
- **Develop a set of guidelines for builders to achieve or exceed this level.**
- **Mandate a mechanical HRV system for all new homes (see Appendix 4 for examples).**
- **Airtightness and ventilation is affordable.**
- **Mandate on-site verification and certification through a blower door test of all new homes to reach or exceed the minimum air tightness target.**

H. Zoning and Airtightness

The general advice SECCCA has provided through its service has been to zone a house with doors as much as possible. However, this has assumed that heating systems are separate or have good zoning controls and an air tightness target has not been set. So that when an area in the house is not being used it's heating and cooling system is switched off and therefore saving energy. For example, zoning off the main living areas from bedrooms and switching between heating appliances as required. This works fine if an airtightness target is not set and a mechanical HRV system (see Appendix 4) has not been installed.

Once a mechanical HRV system is installed there is a source point where the inside air is drawn from. This is typically in a living area and then the system recovers the heat and provides fresh air to other locations such as bedrooms and the old air is drawn from these locations. Therefore, doors in hallways typically used for zoning need to be left open so that air can flow from bedrooms or under bedroom doors to replace the air. The energy efficiency of this systems works as a home sealed to 6ACH@50Pa requires little heating to maintain comfort, as experienced through the case studies. Likewise, in opposite conditions with hotter climates, little cooling is required.

A conflict occurs, zoning is good for energy efficiency if a house is not airtight. However, zoning becomes problematic if a home improves its air tightness as blocking off areas of the house affects the ability of the mechanical HRV system to operate. Given the air quality, health and comfort benefits of improving the airtightness of a home and through installing a mechanical HRV system plus its affordability it is therefore recommended that this approach is within the interests of occupants and best practice.

In conclusion, to regulate only to 10ACH@50Pa without on-site verification and certification exposes the Australian Building Code Board and the Council of Australian Governments to an unknown significant public health risk. The only way to be sure is to mandate air tightness testing and the only way to then ventilate a house safely for those homes that exceed any minimum standard is to mandate a mechanical HRV system. And if airtightness testing and mechanical HRV are mandated then a mandated air tightness standard should be set that significantly improves energy efficiency at an affordable cost verses benefit, such as 6ACH@50Pa.

Lastly, an airtight home that is well ventilated not only improves air quality, energy efficiency and is affordable if future proofs homes to increasing extreme weather events from heat waves to strong winds and rain that can penetrate the home causing moisture and mould issues.

All the builders that were consulted by SECCCA welcomed a 6ACH@50Pa mandated standard. Their main concern is that a level playing field is created with no loopholes. So that, builders adhering to energy efficiency requirements are not put at competitive disadvantage. An independent and robust verification and certification process would resolve those concerns.

Conclusion outcomes:
Do not mandate zoning a home unless there are separate heating/cooling and ventilation systems in operation.
Mandate best practice airtightness, ventilation requirements and verification to avoid a public health risk and improve energy efficiency to reduce heating and cooling loads.
Homes are future proofed from extreme weather through best practice affordable air tightness.

I. Orientation

The advantages of good northern orientation are clear. During winter well orientated living spaces provide passive heating and light. However, it was also clear from the case studies that carbon neutrality can be achieved in poorly orientated homes that are well sealed, double glazed or even single glazed and insulated. This is likely due to when space heating is turned on it only takes a few short minutes to provide the same energy returns as heat from the sun. If the home is well sealed, insulated and double glazed then the generated heat from the appliance stays effective hours on end before further heating is required. The case studies demonstrate this with homes that were rated below 7 Stars by achieving zero or low energy bills when coupled with a solar PV system.

What it highlights is that achieving 7 Stars through significant further building shell upgrades due to poor orientation may not be the most contributing factor to lowering energy demand. The case studies suggest that it is good draught sealing, good insulation and basic double glazing that are key components. So whatever mechanical heating is used to heat the home, the heat stays in the home and does not leak out. This heating can be largely generated from a solar PV system during the day and can hold its heat well into the night for 2-4 hours before additional heating is required. Then the cost of heating is reduced significantly and this is what was observed and experienced by householders living in the case study homes.

Modelling of NatHERS should consider the installation of a mechanical HRV as these systems circulate heat around the home. Homes that are poorly orientated typically have north facing windows in bedrooms or areas that are not main living areas. With a mechanical HRV system circulating air these homes can still take advantage of the passive heat. This could improve the rating of homes simply by installing a mechanical HRV system as the passive heat is circulated for use. Keeping in mind that for these HRV systems to work effectively they require a good level of air tightness, such as recommended at 6ACH@50Pa.

Conclusion outcome:
Orientation whilst important is not as important as draught sealing and air ventilation/circulating through a mechanical HRV system.

J. Evaporative Coolers

Evaporative coolers don't perform when most needed on very hot or humid days. They require a door or window to be left open to remove the moisture. This conflicts with investments in double glazing and insulation. Evaporative coolers also don't work with heat recovery ventilation systems. They should be banned in the National Construction Code.

Conclusion outcome:
Ban evaporative cooling from 2022.

K. 6 or 7 Stars?

As per above, the case study homes are easily achieving carbon neutrality as a 6 Star rated and performing home with some additional upgrades and a solar PV system. An improvement in comfort and air quality through improved airtightness and mechanical ventilation is the first step before considering further improvements in the building shell. As these can be costly and difficult to achieve under NatHERS for poorly orientated blocks. SECCCA recommends that the minimum requirement remain at 6 Star however with 6 Star Plus requirements.

These "Plus" requirements would include 12mm argon filled double glazing, additional insulation in walls and roofs and draught sealing etc as per the recommendations to the NCC code on page 12. It is likely these homes will increase their star rating to somewhere between 6 and 7.5 stars. If the performance goal is carbon neutrality, comfort and health the case studies indicate this is possible within this 6-7.5 Star rating range.

From discussions with several builders, some homes with poor block orientation simply cannot achieve 7 Stars or require very costly additional glazing or insulation. A recent example of an 8 Star home with poor block orientation was an extra $16,000 to get to 8 Star. This is approximately $7,000 extra to improve the building shell over and above the 6 Star Plus homes that are reflective of the net zero carbon homes in the case studies. The $7,000 saving to get from 6 to 8 Stars could have been invested in solar which would have completely offset the homes remaining energy needs, making it net zero carbon.

Furthermore, in this example, if the home at 8 Stars was performing at 10 ACH@50Pa it would likely still have been underperforming in the real world compared to the 6 Star Plus rated home at 6ACH@50a.

Another example is case study home 2 that installed R7 insulation in the roof, R2.5 in the walls, highly efficient hot water heat pump and uPVC, low-e, argon filled 18mm double glazing for an additional cost of $17,000 and it still could not achieve 7 stars (achieved 6.8). This was largely due to the poor orientation resulting in poor solar access. However, this fully electric, 30 square home with a 6kWh solar PV system is easily carbon neutral.

Without solar, this home had low power bills at around $1500 per year. The occupants of this home report that it is very comfortable to live in as it is well draught sealed, requiring only minimum heating. On cold days when it is 8 degrees celsius outside when the heater is off for many hours it will only drop a few degrees to around 16 or 17 from 20 degrees celcius. Cooling is only needed on extreme hot days and again for only a short period of time to drop the temperature in the house.

Conclusion outcomes:
Moving to 7 Stars may be difficult for some homes and expensive.
There are other opportunities such as air tightness that should be rectified first.

L. Compliance – Verification and Certification

SECCCA's views have been formed by the outcomes of the case studies and also interviews with a number of builders about the implications of changes to the building code.

Concerns were expressed by several builders regarding the current verification methods, namely the DTS elemental provisions (3a) and Reference Building Verification Method (3c) whereby homes that were rated at 6 Stars were performing less than the rating. Whilst it is a positive step in the 2019 NCC to include draught sealing requirements to 10 ACH@50Pa without mandatory testing it is of little value and opens up builders to the risk of over sealing homes or not enough. Research from the CSIRO (House Energy Efficiency Inspections Project 2015) has confirmed such outcomes that there are significant issues with many homes performance not matching its NCC rated and modelled real world practice.

Compliance pathways should be onsite, whole-of-house and include a blower door test to verify air tightness. This verification and certification would cost approximately $700 per house if done on scale. Homeowners are making significant investments in energy efficiency to reduce energy bills, improve comfort and health. It is a consumer right to receive what they paid for through these significant investments and the NCC should create a transparent and robust verification and certification process to protect consumers and potential liability issues should energy efficiency specifications not be delivered. The only way to ensure this is through an onsite whole-of-house verification process such as the Victorian Residential Efficiency Scorecard for the building fabric and appliances specification and a blower door test for airtightness.

Every participant and builder that received this verification and certification were impressed with the ability of these methods to clearly and independently interpret what had been achieved in their home. The results of these tests always correlated with the living experience of the occupants of the home.

Some builders have suggested that to avoid the per house verification and certification and blower door test cost, that these could be completed for 1 in 10 or 1 in 5 homes. However, the issue with tightening homes is that each home can be built differently, by different trades and result in different levels of air tightness. This approach could result in some houses with over or under tightening leading to undesirable health effects or increase in energy costs despite investments. In the interests of public health and achieving verifiable energy efficiency targets and outcomes for all homes and their occupants, the expense of verification and certification is a worthy and mandatory investment.

Two additional checks are recommended by Builders Surveyors to check draught sealing and insulation. These two checks should occur prior to insulation and prior to plaster. These costs would be around $150 each for a half hour onsite visit by a Building Surveyor to check draught sealing and insulation according to guidelines developed under the NCC.

It is well documented that there are non-compliance issues relating to the energy efficiency requirements under the NCC. One builder made the comment that they are ensuing their homes are meeting and performing to the 6 Star standard, despite the industry knowledge that many builders are using loopholes to pass the current DTS methods on paper only. However, if the star rating were raised to 7 Stars and there is no robust onsite independent verification of homes in the marketplace to create a level playing field then they could not possibly continue to compete due to the cost implications to achieve 7 Stars. They then would also have to consider using the same loopholes and start meeting the DTS requirements on paper however not in practice.

SECCCA's position is that for $1000 any issues can be identified and rectified to ensure public health and energy efficiency targets are achieved. Much like a car must obtain a roadworthy check, so to a house should also gain a liveability and energy efficiency check to ensure proper performance and protect consumers, builders and regulators.

Conclusion outcomes:
Mandatory on-site verification and certification. Two additional onsite pre-insulation and pre-plaster checks should also occur, with photographic evidence collected by the Building Surveyor. This could also be conducted by the final whole-of-house verification assessor, such as a Scorecard Assessor.

M. Cost Implications

The following table represents an approach that sets the minimum standard at 6 Star with the additional requirements, what we have termed '6 Star Plus', over and above what is required under 6 Stars currently. However, these items cannot to be traded off under the 6 Star compliance standard, they must be additional. This will allow for a sliding scale for the final star rating depending on how poor or well a house is orientated and enable the design of the house to maximise the solar gain.

It also treats all homes equally across the country. The reason for this is that ultimately no matter where you live, if it is hot or cold, residents can be comfortable at either end of the extreme. Air space in the home needs to be controlled with a space conditioner with either hot or cold air/fans. Also, to prepare for the extremes of hot or cold in temperature that are occurring under climate change, it is now more than ever critical to control the air space.

Table 5 - 6 Star Plus specifications, justification and costs for the average new home

The average new home is approximately between 25 and 30 squares. This size has been used to demonstrate the affordability of the energy efficiency requirements. Prices will vary from builder to builder however is a general indication based upon the costs incurred to participants in the case studies so are reasonably accurate.

Recommended Requirements – 6 Stars Plus Policy	Justification	Assumed additional costs for an average new home
1. Installation of an appropriately sized renewable energy system such as a solar PV system to offset 100% of energy needs	Renewable energy enables the complete generation or offset of remaining energy needs. The technology is highly affordable and should be mandated for all new homes. See table 6 below.	$5000 (inc. federal rebate) 5kWh sized system
2. Standard 12mm Argon filled double glazing of all windows and glass doors	Argon 12mm double glazing triples the benefit of single glazing. It also reduces noise and provides a significant increase in the ability of a window to be sealed due to its rigidity. (uPVC, thermally	$4000 -$5000

	broken, low-e etc have been omitted due to the significant additional cost with a diminishing return on investment vs. improvement in energy efficiency, as demonstrated by the case studies)	
3. Increase of insulation in walls across all climate zones to 2.5 in the walls and in roofs R5 in the roof	This is the most sensible investment. It ensures maximum insulation in the walls and roof. R6 in the roof was considered however due the additional weight compared to R5 homes would require battening in the roof to hold the insulation up. R2.5 is the maximum level of insulation possible in standard walls. This maxing out of insulation also offsets the loss of insulation value caused by thermal bridging through the timber or metal frame of a home, which is currently not factor in.	$2000
4. Evaporative cooling (Assume $5,000) and gas ducted heating ($2,000) be banned and replaced by refrigerated reverse cycle heating / cooling or electric heat pump (or could use hydronic heating)	Without evaporative cooling and gas ducted heating the most affordable option are single split systems offering both heating and cooling. A number of case studies used single splits in living areas and multi-splits in the bedrooms. Multi-splits for the bedrooms were found to be expensive to install and were over engineered for the small bedroom spaces. A simple heat transfer kit from the heat source in the main living room can provide heating and cooling to the bedrooms from a main living area. Keeping in mind that once a HRV system is installed then it is ideal that all the areas are ventilated and therefore heated to ensure there are no spots in the house that become stuffy.	$0 extra over and above the cost of an evap/gas - for a single split in the main living area (approx. 6-8kWh) (coupled with the heat transfer kit mentioned below for circulation throughout the house to the bedrooms) Assumes two splits $3,000 – one each in two living areas
5. A shading strategy completed and implemented for all windows to ensure east and west windows can to block out the sun (e.g.	The hot summer sun on the east and west windows can considerably increase the cooling requirements of a home unnecessarily. To avoid this radiant heat gain the only option is to block the sun	$1000 - $2000

	eves, awnings, block out blinds, roller shutters, pergolas, etc.)	out from entering the home. Ideally, this block out should occur outside the house from an eve, awning, roller shutter or pergola. However, on facades this could include block out blinds that work very effectively while maintaining the integrity of the façade.	
6.	Installation of an electric boosted solar hot water service or heat pump hot water service (I.e. not an option to opt for a water tank instead under NatHERS). Gas hot water heating to be banned	This additional cost is for a high efficiency heat pump, such as a Sanden Heat Pump. Ideally a heat pump is used as it is typically seen on new homes is that the two solar hot water panels are placed directly in the middle of the northern roof space directly in way of where the best location is for a PV solar array.	$1000
7.	Airtightness works on all new homes with a minimum level of 6ACH@50Pa required	Builders have commented how easy it is to improve the air tightness of a home. Using tapes, corking and foam as many cracks and holes that can be found are sealed. Particular attention should be paid to light fittings, sliding doors and any extrusions to the home. These incudes as far as practicable ensuring all insulation is installed properly and is not unseated by electrical wires or plumbing pipes.	$500
8.	Mechanical HRV – Installation of a centralised system for all main living areas (coupled with an air transfer kit to all bedrooms) or decentralised system (servicing all main areas and bedrooms) heat recovery and ventilation system (drawing air from outside the house, i.e not the roof space)	If significant investments are to be made in insulation and double glazing, then these investments can be null and void if an appropriate level of airtightness is not achieved to effectively keep the hot or cold air in. The science (Your Home Technical Manual) shows at 6ACH@50Pa there is a small – occasional need to ventilate. For HRV systems to work effectively they need be sealed to around this level. Also given that some homes will unintendedly be tightened	Centralised with a heat transfer kit $0. Assumes $1500 HRV $0 Centralised system x 2 in two main living areas $2500 Decentralised servicing living spaces and

	further then the installation of a mechanical HRV systems is needed. Case studies have demonstrated that those homes have been well sealed to these levels retain their heat or cool air over long periods of time, 2-4 hours. In the most basic set up using a centralised system and an air transfer system the cost of a multi-split is avoided and provides the added values of fresh filtered air from outside. A mechanical HRV system safeguards the health and comfort of occupants.	bedrooms ($7,000-$10,000)
9. Victorian Residential Efficiency Scorecard assess-ments or similar of all new homes and an air tightness test to confirm compliance plus two additional Building Surveyors verification checks to draught sealing and insulation (including photographic evidence to be forwarded to the VRES Assessor)	Once any airtightness target is set and significant investments are made in energy efficiency its performance needs to be verified and certified. This protects the interests of the consumer, the builder and the regulator from any potential issues related to public health, damage from moisture related issues such as mould and additional energy costs if homes are found to underperform from poor workmanship.	$500 Blower door test $300 2x builders surveyor checks $300 final VRES or similar assessment
10. Avoided cost of gas plumbing installation and connection	Arguable these costs are replaced by electrical cables. However, a gas connection is not required or plumbing to the house. There is a saving as only one trench is required to service the house.	-$1000

N. Preliminary energy budget to ensure net zero carbon homes

The following provides a preliminary look at what an appropriately sized solar PV system is compared to the size of a home and its energy use. They are approximations based on participants reported energy needs and can be useful in considering targets and budgets to achieve zero carbon homes.

Table 6 - Preliminary Energy Budget

Notes: The budget assumes that the example houses have been built to a 6 Star Plus standard (fully electric) and is verified and certified.

Number	House size (squares)	Energy bills (24 cents per approx. per. kwh) pre solar	Annual energy budget (based on ave. 23kWh a day)	Renewable energy system size (kWh) 1kw = 1500kWh	kWh generated annually from solar system	Capital upgrade cost (with fed. Gov. rebate) approx.
1	<20	$950	4,000	4	6000	$4,000
2	25	$1,450	6,000	5	7500	$5,000
3	30	$1,900	8,000	6	9000	$6,000
4	35	$2,400	10,000	7	10,500	$7,000
5	40>	$2,900	12,000	9	13,500	$9,000

O. Comparing performance goals, costs and understanding the lived experience

The following Table 7 brings all the learnings together and demonstrates household energy performance goals and outcomes in relation to energy efficiency and renewable energy requirements and associated increasing costs to achieve these goals. It is based on costs experienced by the 7 case study participants, discussions with builders and suppliers and a number of other case studies under development to illustrate the costs of increasing to 7 or 8 Stars, passive homes and beyond. The table is not exhaustive of the options however is illustrative of the costs and potential combination of cost outcomes given various scenarios.

Essentially, the table helps determine what is the "sweet spot" balancing the cost to achieve net zero carbon. Assuming the two primary performance goals are carbon neutrality and affordability. Most importantly the performance outcomes or 'lived experience' demonstrates the real-world value to occupants.

Defining the performance goal is a critical consideration before a purchaser or a regulator specifies energy efficiency and renewable energy requirements. There is much confusion in the community and building industry about what "makes" a home energy efficient and where best to spend capital to achieve the greatest outcome. The Your Home Technical Manual[1]*1 is an excellent resource with hundreds of pages of

[1]http://www.yourhome.gov.au/

ideas however no definitive direction on what to do or can be done in the volume home market for greatest effect.

A purchaser or builder wanting to improve the energy performance of their home beyond the minimum standard in the current marketplace should consider what's important to them through the following goals, which could be defined as four distinct market segments:

1. **Net zero carbon** – operationally generating or offsetting more energy than needed (additional renewable energy feed into the grid offsets emission from gas use)
2. **Net zero carbon and 100% electric** – generating more energy than needed with no operational carbon emissions (no gas connection) and with good air tightness
3. **Passive House** – Minimal heating or cooling requirements with excellent improvements in air quality and comfort (does not consider other appliance energy use however can incorporate if desirable by purchasers)
4. **Energy independence** – some or complete protection from power outages through a solar PV system and battery storage and connected to the grid.

This will determine what direction and level of energy efficiency, renewable energy and battery energy storage systems are required. Likewise, government regulators in consideration of raising minimum standards should consider what they are aiming to achieve. An increase in energy efficiency performance is directly related to increasing cost. Whilst it is unlikely that energy efficiency costs might decrease, solar and battery storage costs continue to decrease as uptake increases. This has implications for increasing further building shell performance. Any new regulations should take this into consideration and factor in future adaptability.

The below table shows the quick escalation of capital costs with diminishing returns for many options over and above the goals of achieving zero carbon, improved air quality and comfort. These goals can all be achieved affordably by ensuring good building practices, specifying particular products and verification. The National Construction Code should set this standard at a minimum. Beyond this the other options can remain as aspirational voluntary undertakings by builders and consumers in the marketplace for those building or buying a new home. It's on this basis that SECCCA has developed an alternate trajectory that takes these points into consideration.

Table 7 Performance Goals Comparisons

Performance Goal	NatHERS Star Rating (Out of 10 stars)	RES Star rating (Out of 10 stars)	Hot Weather Rating (Out of 5 stars)	Accumulative Energy Efficiency specification Note: costs are approximate and will vary from house to house and builder to builder	*1. Approximate Costs	Accumulative cost above current minimum standards	Performance Outcomes …the "lived experience"
1.**Pre standards** Houses built prior to 2003 (in 1990 most houses averaged 1 star)*2	<5 Star	<5	0	Reliance on building fabric for protection from the elements – no minimum insulation	$0	NA	Cold and hot always. Reflective of outside environment. Requires significant and costly heating and cooling. Gas and Electricity bills > $3000 annually
2. **NatHERS 6 Star Compliance** Compliance approach to with minimum energy efficiency standards **MAJORITY OF NEW HOMES TODAY** **No verification methods – relies on design standard not on-site as built**	6 Stars	6 Stars	1	Consideration of orientation and other aspects, building materials, window sizes, flooring etc *Insulation minimum R1.5 Walls and minimum Insulation R3.5 Roof $3k (also depends on climate zone) *Sustainability Victoria Solar hot water service (gas or electric boosted) or water tank $2k Glazing requirements – depending on NatHERS assessment may require double glazing Draught sealing as per building code	<5k*5. extra	NA	Requires regular heating and cooling Typically uses gas heating and evaporative cooling Gas and electricity bills > $2500 annually

				Evaporative cooling and gas ducted heating ($7,000 however not included as an additional cost) No verified performance and does not consider overall energy requirements of a home			
3. **Net Zero Carbon** House uses on average no more energy than it generates Minimal reliance on gas (can still occur for, heating, hot water and cooking). Solar system offsets carbon emissions from gas use	6-7 Stars	10 Stars	2-3	As above plus: R2.5 in walls and R5 Roof – $2.5k Standard 12mm Double Glazing (R0.3) (argon filled) 3x better than single glazing $5k Shading strategy implemented $1k Efficient zoned gas heating $1k 5kWh solar (worth 3-4 RES stars) $5k (with fed. govt. rebates) Zoning heating spaces 2x door doors/sliding doors $500 On-site whole-of-house verified and certified RES $300 Two additional building surveyor visits, prior to insulation and plaster $300	<$17k extra	$17k	Minimal heating and cooling required Low, zero or positive electricity bills annually. Likely that gas use is offset by PV generation. Small gas bill < $1000 annually Improved level of comfort
4. **Net Zero Carbon & 100% Electric** (operationally carbon neutral house)	As above	As above	As above	As above plus: Electric cooking oven/stove $1k Hot water (high efficiency heat pump, no gas) $1k	<$3k	<$20k	Minimal heating and cooling No electricity or gas bills Improved level of comfort

				Draught sealing to <6ACH@50Pa - $500 6kWh Reverse cycle splits to living area x2 ($3k) and heat transfer kit to x4 bedrooms ($1.5k) = $4.5 - $7k (cost of gas ducted and evap. cooling swapped out) = - $2.5k **(alternative to this system is a multi-split for $6,000)** Mechanical HRV (2x centralised for 2 main living areas) to provide heat recovery and constant fresh ventilated air - $2.5k **(alternative to this system is a decentralised system for $10,000)** Verified and certified blower door test to 6ACH@50Pa $500	**Or alternative** **<$16k**	**Or alternative** **<$33k**	
5. **Zero Carbon plus battery** As above plus battery storage and with grid black out protection	As above	As above	As above	As above plus: For the most part energy created and stored and used by the house. Battery system (8-10kWh) still interacts with the grid and draws power as required however in the event of a power outage, stored power in the battery can run basic appliances. (no back-up generator) <$15k	<$15k	$35k	Largely energy independent from the grid however still connected to enable feeding in with excess energy
6. **Zero Carbon plus further improvements in building shell to increase star rating to 7-8 Stars** Achieved through additional glazing	7-8 Stars	As above	As above	As above plus: Additional insulation in roof to R7 and or additional wall insulation $2k Additional glazing 20mm, Argon filled, uPVC, low-e, thermally broken etc (2x good as standard double glazing R0.6) $13k	$15k	$50k	As above plus better insulation / glazing

specifications and insulation							
7. **Aspirational Passive House** (or Passivhaus certified)	9-10 Stars	As above	3-5	As above plus: Double (argon filled, low e, uPVC) or triple glazed windows $15k Additional ridged insulation requirements or double stud walls $20k+ Additional airtight membrane $20k+ Constant Energy recovery ventilation system required $10k Verification of all requirements plus must meet energy performance goals if certified under Passivhaus *4	$65k +	$105k +	No heating and cooling required Higher level of comfort Excellent air quality filtering out pollutants such as pollen and dust
8.**10 Stars and Beyond**	As above	As above	As above	As above plus: Green Walls Life cycle considerations Ethical and recycled products	?	?	Minimal overall environmental impact
9.Off Grid House	As above	As above	As above	Using a battery system or generator to supply all outstanding energy needs and not connected to the grid	?	?	Complete energy independence

*1 Notes costs are indicative and approximate. They vary depending on specified product and brands, as well as house sizes.

*2 http://www.nathers.gov.au/owners-and-builders/star-rating-scale-overview

*3 http://www.build.com.au/bca-requirements-insulation

*4 https://www.passivehouse-international.org/index.php?page_id=80

*5 https://www.abc.net.au/news/2017-10-10/construction-loophole-leaving-buyers-with-higher-energy-bills/9033916

P. CONCLUSION

In principle, SECCCA is supportive of lifting the NatHERS Star rating from 6 to 7 Stars as any improvements to the building shell are beneficial for energy efficiency and reducing carbon emissions.

However, if affordability and net zero carbon are key considerations, then SECCCA suggests that from 2022 a third option is available to the ABCB in the NCC. This is Option 3, the 6 Star Plus as discussed. SECCCA's NHEAS project outcomes demonstrate that for around $20,000 the average home can become net zero carbon while significantly improving comfort and health. This is achieved through good airtightness, glazing and insulation whilst improving indoor air quality via a mechanical HRV system.

If a further $10,000 to $15,000 is available, (the cost to get to 7 Star rating in some cases in addition to the $20,000 to achieve net zero carbon) then this capital could be spent on installing a 4-8 kWh battery system. This would assist management of peak grid loads if a 'dynamic' demand control device were fitted to solar inverters.

If increasing the Star rating is still desirable table 8 below outlines a possible alternate trajectory available in the NCC that also allows for time to consider how to assist poorly orientated homes to reach 7 Stars. For example, it may be the case that to enable all homes to reach 7 Stars changes need to be made to the Planning Scheme in all States and Territories to ensure block orientation maximises northern solar access. This will take time to move through the planning process.

In the meantime, these 6 Star Plus homes would reach a minimum of 6 Star or more and net zero carbon once the additional energy efficiency requirements are applied, for example:

Example House	Minimum onsite verified 6 Star compliance	Orientation and living space design	Onsite verified 6 Star Plus after additional energy efficiency initiatives	Carbon Neutrality
1	6 Stars	Good	6.5 Stars	Net zero or positive
2	6 Stars	Excellent	7.3 Stars	Net zero or positive
3	6 Stars	Poor	6.1 Stars	Net zero or positive

The trajectory over the next decade could see the star rating lifted from 6 star or up to 7 or further if need be. However, this should consider affordability verses other interventions such as solar or batteries that could a better investment option. For example, if it costs an additional $15,000 to get to 7 Star for a poorly orientated home then these funds could be better spent on an 8kWh battery system that could store up to 16 kWh of energy with 2 cycles every day. With an approximate 23kWh winter daily energy use this would mean a home would need to draw from or export very little power to the grid.

Table 8 NCC Option 3 – 6 Stars Plus Trajectory

<table>
<tr><th>Year</th><th>Action</th></tr>
<tr><td>2021</td><td>Review Trajectory to consider staggered approach to increasing the star rating. Create energy budget for homes with aim to be net zero carbon starting 2022.</td></tr>
<tr><td>2022</td><td>In the NCC (Option 3 – 6 Star Plus)

1. 6 Star Plus (must meet minimum 6 Star current requirements plus additional requirements – this may and will lift many homes to beyond 6 Stars, possibly up to 7.5)
2. Plus an appropriately sized solar system to offset the remaining power needs based upon a set energy budget as per example in Table 7.
3. Plus Double Glazing (Argon filled, 12mm)
4. Plus insulation upgrade to R2.5 in the walls and R5 in the roof
5. Plus draught sealing to less than <6ACH@50Pa
6. Plus a centralised or decentralised mechanical heat recovery ventilation system (HRV)
7. Plus shading strategy implemented
8. Plus verification and certification through an independent onsite assessment including a blower door test and whole-of-house assessment such as the Residential Efficiency Scorecard to achieve 10 stars.
9. Plus two additional building surveyor visits must also occur prior to insulation to check draught sealing according to guidelines and prior to plaster to check that insulation is installed correctly. Photo evidence required to be passed onto the Scorecard Assessor.
10. Plus introduce ‘dynamic’ demand control device on inverters to ensure issues with grid stability and voltage are managed
11. Plus if homes exceed the energy ‘budget’ or unable to install solar they must purchase accredited Green Power

Gas connection, gas appliances and evaporative cooling removed from the building code. Homes to be fully electric.</td></tr>
<tr><td>2024</td><td>Review the Trajectory and results of homes built to NCC 2022</td></tr>
<tr><td>2025</td><td>In the NCC

1. Increase to 6.5 Stars minimum standard in homes if required
2. Adjust the energy budget as required to match the size solar system to energy needs to offset all electricity consumption and achieve net zero carbon (table 7)
3. Consider minimum battery storage requirement for all households to manage grid stability if required</td></tr>
</table>

	4. Review new technologies to be added as alternate options to achieve net zero carbon
2027	Review the Trajectory and results of homes built to NCC 2025
2028	In the NCC 1. Increase to 7 Stars minimum standard in homes if required 2. Adjust the energy budget as required to match the size solar system to energy needs to offset all electricity consumption and achieve net zero carbon (table 7) 3. Consider minimum battery storage requirement for all households to manage grid stability if required 4. Review new technologies to be added as alternate options to achieve net zero carbon

Finally, SECCCA recommends further consultation with builders to establish the cost implications of the proposed Options 1 and 2 in the NCC Scoping Study. This will provide further clarification of the affordability implications of the proposed options and inform future decisions considering the preferred performance goals.

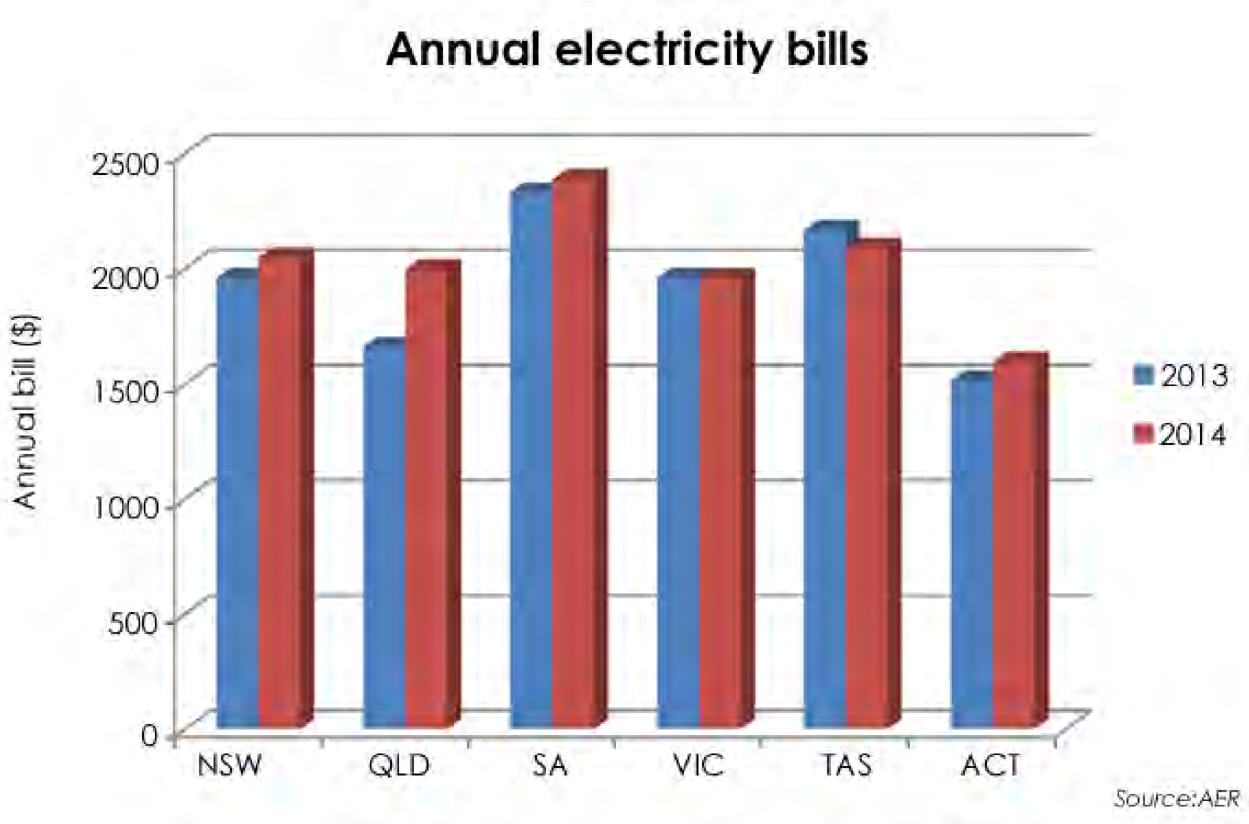
Appendix 1 - Comparison of typical window (frame and glass) R-values

Window frame material	Single glazing	IGU with 4 mm glass and 8 mm air space	IGU with 4 mm glass and 12 mm air space	IGU with 4 mm glass, 12 mm air space and low-e pane	IGU with 4 mm glass, 12 mm air space, low-e pane and argon gas fill
Aluminium	**R0.15**	**R0.25**	**R0.26**	**R0.31**	**R0.32**
Thermally broken aluminium	**R0.17**	**R0.30**	**R0.31**	**R0.39**	**R0.41**
Timber	**R0.19**	**R0.34**	**R0.36**	**R0.47**	**R0.51**
uPVC	**R0.19**	**R0.34**	**R0.36**	**R0.47**	**R0.51**

The actual R value of a window is dependent on the glazing, frame material and window size.

Source: NZS 4218:2009 Thermal insulation – Housing and small buildings (provided by Standards New Zealand under licence 001148).

Appendix 2 – Cost of Electricity and Gas Annually



https://www.abc.net.au/news/2015-03-25/electricity-chart-1/6346630

https://www.canstarblue.com.au/electricity/average-electricity-bills/

https://www.canstarblue.com.au/gas/compare-natural-gas-victoria/

ABC fact check from 2014 approx. $1900 on average households

Canstar Blue Electricity approx. $1602 on average households

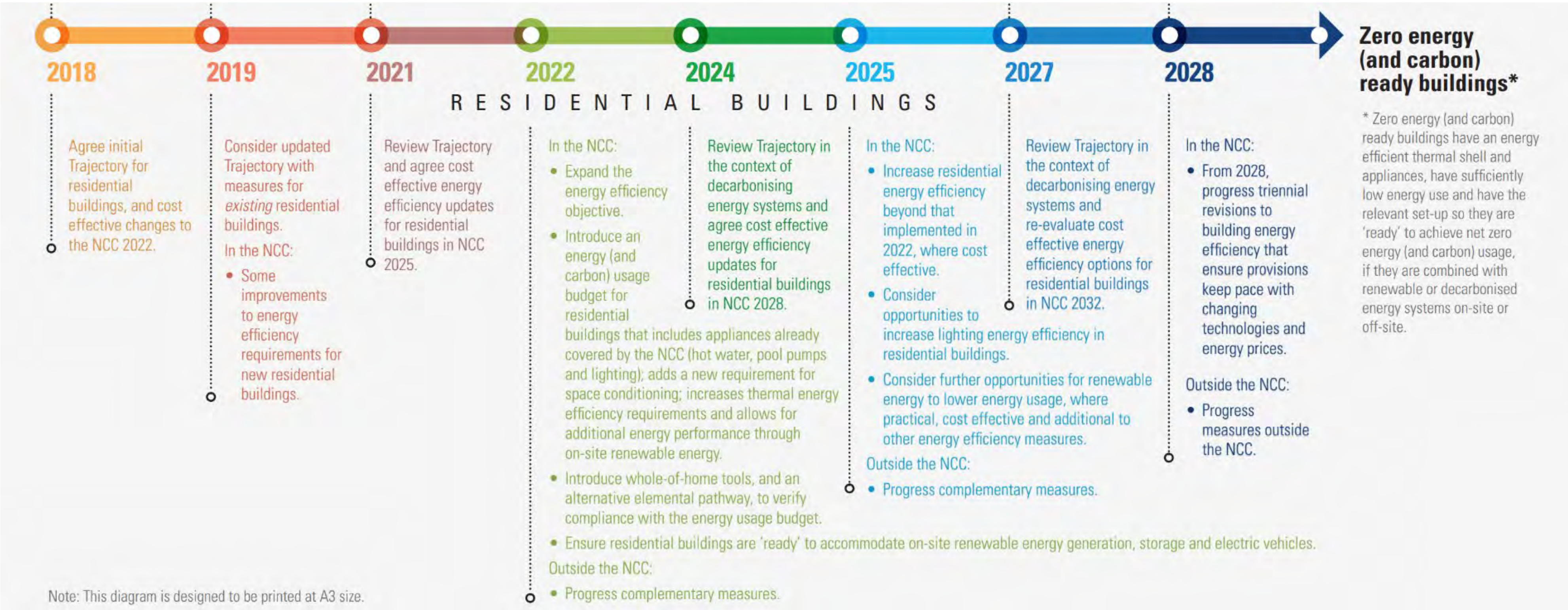
Canstar Blue Gas approx. $1267 on average for households

Therefore, assume a conservative $2500 for both gas and electricity per year on average for a single household.

Costs to increase 6-10star NatHERS

https://researchbank.rmit.edu.au/eserv/rmit:160284/Moore.pdf

Appendix 3 COAG Trajectory as referred in NCC Scoping Study Table 9 Draft COAG Trajectory as referred to in the NCC Scoping Study



Appendix 4 Heat transfer Kits and Mechanical Ventilation Options

Heat Transfer Kits

https://www.universalfans.com.au/heat-air-transfer/

http://www.pureventilation.com.au/heat-transfer/

Centralised Mechanical HRV

https://www.universalfans.com.au/online/fanco-habitat-heat-recovery-dc/

Decentralised Mechanical HRV

https://www.universalfans.com.au/buy/heat-recovery-ventilation/

Appendix 5 Case Studies

See attached file

NEW HOME ENERGY ADVISORY SERVICE

CASE STUDY ANALYSIS 01.

Case 01.

Occupants:
A couple living with
3 school aged children.

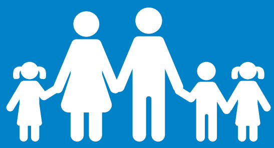


Table 01.

Key upgrades (beyond the minimum 6star NatHERS) and Costs

The following are the upgrades and outcomes of a 29 square home recently built in Clyde North.
Please refer to the SECCCA Toolkit for further details of the key upgrades and rating systems.

NUMBER	KEY UPGRADES	TYPE OF ACTION	COST EXTRA	POINTS
1	Maximised orientation of living spaces north	Passive	$500 Change to Driveway	1
2	An appropriate Shading Strategy (including eaves, awnings, pergolas, reducing window sizes, block out blinds etc)	Passive	$500 Change to Window Plans	1
3	Upgrade insulation in roof and walls	Building Fabric	N/A	0
4	Double Glazing	Building Fabric	$3000	1
5	Good – Excellent Air Tightness	Building Fabric	N/A	1
6	Efficient Solar Hot Water or Heat Pump	Appliance	N/A	1
7	Fully Electric	Appliance	N/A	0
8	Efficient electric reverse cycle heating and cooling system	Appliance	$5000 Upstairs Bedrooms Only	1
9	Solar PV System	Generate Power	$4400 Ex Rebate = $2200	0
10	Battery Storage System	Store Power	N/A	0
TOTAL POINTS			**$11,200**	**7**
PAYBACK: 7.2 YEARS*				
SAVINGS AFTER PAYBACK BETWEEN 7.3 AND 15 YEARS			**$16,308**	

*Notes: additional $4000 to met minimum 6 star requirement = Total $15,200. Assumes typical bill saving of $1602 annual electricity and gas $316 -$200 quarter = $116 or $516 annually. Total electricity $1602 + $516 gas = $2118 annual saving

Additional upgrades:

- Flipped house plans and driveway to access northern orientation – cost $500 for new driveway.
- Ducted gas to living spaces with upgraded zone control with reverse cycle split system upstairs.

Table 02.

Energy Ratings and Power Bills

RATING / TEST / OUTCOMES	OUTCOME
NatHERS	6.1
Victorian Residential Efficiency Scorecard	10 Stars
Blower Door Test	6.7 ACH50 – Good
Energy Bills	Electricity: Net $0 Gas: $200 a quarter

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NEW HOME ENERGY ADVISORY SERVICE

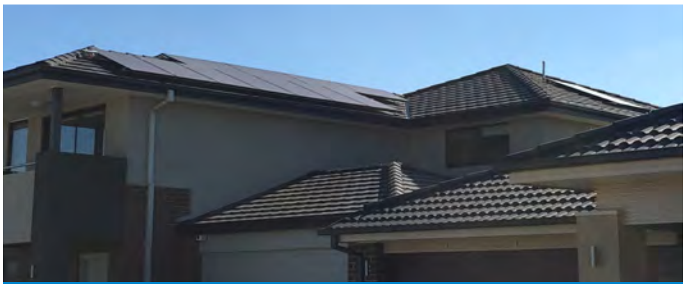
CASE STUDY ANALYSIS 01.

R4 in the roof, however some batts were displaced

Benefits

as reported by the homeowner:

- Reduced power bills
- Double glazing makes the house quieter from outside noise
- Additional light in the living spaces during winter



6.2kw Solar System

Barriers

as reported by the homeowner:

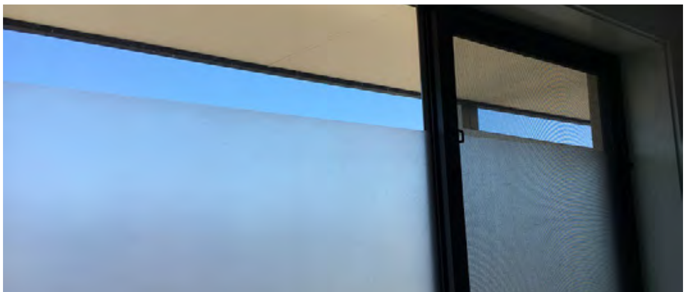
- Builder didn't want to make changes however after persistence agreed on some things

Conclusion

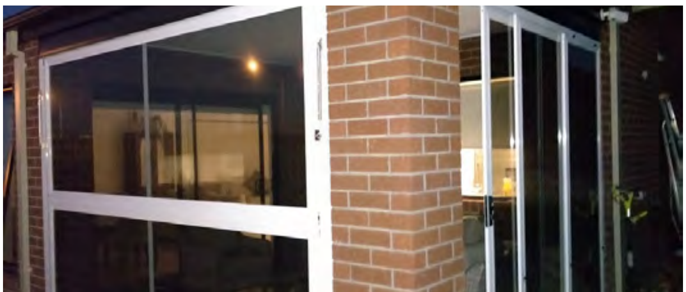
This house achieved 7 out of the 10 key recommendations through the program at a cost of $11,200.
As a result the house was highly rated under the Residential Efficiency Scorecard however this did not move the NatHERS rating.

The home was air tight within recommendations.
As a result of the use of efficient appliances such as lights, hot water heating and heating and cooling coupled with solar this house uses zero net electricity. However due to boosting hotwater heating, cooking and downstairs heating with gas the house still attracts a gas bill of $200 a quarter.

Efficient reverse cycle split system used upstairs



Double glazing used throughout the house



Alfresco retractable doors for shading and wind protection

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CASE STUDY ANALYSIS 03.

Case 03.

Occupants:
A couple living with 2 young children.

Table 01.

Key upgrades (beyond the minimum 6star NatHERS) and Costs

The following are the upgrades and outcomes of a 29 square home recently built in Clyde North. Please refer to the SECCCA Toolkit for further details of the key upgrades and rating systems.

NUMBER	KEY UPGRADES	TYPE OF ACTION	COST EXTRA	POINTS
1	Maximised orientation of living spaces north	Passive	N/A	0
2	An appropriate Shading Strategy (including eaves, awnings, pergolas, reducing window sizes, block out blinds etc)	Passive	N/A	0
3	Upgrade insulation in roof and walls	Building Fabric	$500	1
4	Double Glazing	Building Fabric	N/A	0
5	Good – Excellent Air Tightness	Building Fabric	N/A	0
6	Efficient Solar Hot Water or Heat Pump (ie. not a Water Tank)	Appliance	N/A	1
7	Fully Electric	Appliance	N/A	0
8	Efficient electric reverse cycle heating and cooling system	Appliance	$4000	1
9	Solar PV System	Generate Power	N/A	0
10	Battery Storage System	Store Power	N/A	0
TOTAL POINTS			**$4,500**	**3**
PAYBACK: 6.7 YEARS*				
SAVINGS AFTER PAYBACK BETWEEN 6.7 AND 15 YEARS			**$10,491**	

*Notes: additional $4000 to met minimum 6 star requirement = Total $8,500. Assumes typical bill saving of $400-$300 = $100 quarter or $400 annual electricity and gas $316 -$100 quarter = $216 or $864 annually. Total $400 + $864 saving = $1264 annual electricity and gas saving.

Additional upgrades:

- Internal Shutters.

Table 02.

Energy Ratings and Power Bills

RATING / TEST / OUTCOMES	OUTCOME
NatHERS	TBC
Victorian Residential Efficiency Scorecard	7
Blower Door Test	7.74 ACH50 < Good
Energy Bills	Electricity: $300 a quarter Gas: $100 approx a quarter

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CASE STUDY ANALYSIS 03.

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Some eves to the south however missing in key areas to the east and west on upstairs bedroom windows

Fan venting directly into roof space without draft stopper

Benefits

as reported by the homeowner:

- Bills are a lot lower than previous houses.

Barriers

as reported by the homeowner:

- Builder was not receptive to changes, we did what we could.

Conclusion

This townhouse achieved 3 out of the 10 key recommendations through the program at a cost of $4,500.

The house was rated 7 stars under the Residential Efficiency Scorecard however this did not move the NatHERS rating. The RES rating is quite high and is likely due to the smaller size of the home comparable to other homes on which the rating system compares. There were some attempts made at better shading and orientation however the owner found it difficult to get these accepted by the builder.

The home was just within the air tightness recommendations. Upgrading the insulation to R6 in the roof will have helped increase the internal comfort of the home on hotter days and coupled with an efficient reverse cycle split system result in lower heating and cooling bills.

Had the home installed a solar system their electricity bill would have close to zero. As gas is still used for boosting hot water heating and gas cooking a gas bill of $100 a quarter still occurred.

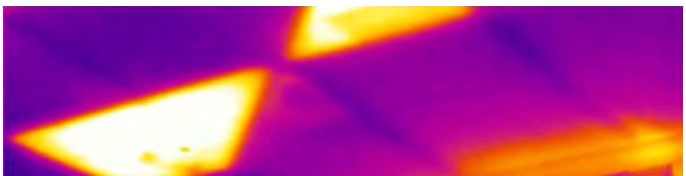
The owner complained of dust in the upper bathroom. This was investigated and found to be due to the bathroom fan venting straight into the ceiling space without a draft stopper. An exhaust fan with built in backdraft shutter can be installed at very little additional cost, saving on cleaning and heating and cooling bills.

Thermography testing showed that there were approximately 6 places were batts were missing or displaced. It also showed up areas where there were air leakages around window architraves, fans and heating and cooling units.

Efficient reverse cycle heating and cooling units installed throughout

Gas boosted solar hot water unit

Thermography test showing air leakage from upstairs fan without draught stopper



Thermography test showing air leakage from missing or misplaced insulation batts

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CASE STUDY ANALYSIS 04.

Case 04.

Occupants:
A couple with a new-born baby.

Table 01.

Key upgrades (beyond the minimum 6star NatHERS) and Costs

The following are the upgrades and outcomes of a 24 square home recently built in Officer.
Please refer to the SECCCA Toolkit for further details of the key upgrades and rating systems.

NUMBER	KEY UPGRADES	TYPE OF ACTION	COST EXTRA	POINTS
1	Maximised orientation of living spaces north	Passive	N/A	0
2	An appropriate Shading Strategy (including eaves, awnings, pergolas, reducing window sizes, block out blinds etc)	Passive	$0	1
3	Upgrade insulation in roof and walls	Building Fabric	$1800	1
4	Double Glazing	Building Fabric	$0	0
5	Good – Excellent Air Tightness	Building Fabric	$0	1
6	Efficient Solar Hot Water or Heat Pump (ie. not a Water Tank)	Appliance	$0	1
7	Fully Electric	Appliance	N/A	0
8	Efficient electric reverse cycle heating and cooling system	Appliance	N/A	0
9	Solar PV System	Generate Power	$5000	1
10	Battery Storage System	Store Power	N/A	0
TOTAL POINTS			**$6,800**	**5**
PAYBACK: 4.6 YEARS*				
SAVINGS AFTER PAYBACK BETWEEN 6.7 AND 15 YEARS			**$24,190**	

*Notes: additional $4000 to met minimum 6 star requirement = Total $10,800. Assumes typical bill saving of $1602 annual electricity and gas $316 -$135 quarter = $181 or $724 annually. Total $1602 + $724 saving = $2326 annual electricity and gas saving.

Additional upgrades:

- LED lights $120 each
- Hebel upgrade $4,000

Table 02.

Energy Ratings and Power Bills

RATING / TEST / OUTCOMES	OUTCOME
NatHERS	6
Victorian Residential Efficiency Scorecard	10
Blower Door Test	5.3ACH50
Energy Bills	Electricity: $0 Gas: $135 a quarter


Gas ducted heating unit installed in the roof space


R6 insultation installed correctly in most places

Benefits

as reported by the homeowner:

- Cooler during summer as well. Only ever used the evaporative cooler on the hot days. Generally just a more comfortable home.
- Power bill is in credit and receiving 20c for feed in tariff.

Barriers

as reported by the homeowner:

- Cost. We would have liked to have done more, however any upgrades from the builder were overly expensive.

Conclusion

This house achieved 5 out of the 10 key recommendations through the program at a cost of $6,800 extra.

The house was highly rated under the Residential Efficiency Scorecard, however the changes did not move the NatHERS rating.

The home was air tight within recommendations. As a result of the use of efficient appliances such as lights, hot water heating and heating and cooling coupled with solar this house uses zero net electricity. However due to boosting hot water heating, cooking and downstairs heating with gas the house still attracts a gas bill of $135 a quarter.

The occupant expressed disappointment in the comfort levels in the house, despite a high energy rating. This may be attributed to a lack of double glazing given that the house was well sealed and had increased insulation levels above the standard. There was also disappointment that when it got too hot that the evaporative cooling didn't work well and as a result are looking at installing a further refrigerated cooling system in the living space.


Example of an area of insulation installed poorly


Installed a number of smaller windows to east and west


Installed a 4kw solar system

NEW HOME ENERGY ADVISORY SERVICE

CASE STUDY ANALYSIS 05.

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Case 05.

Display House Open to the Public

Contact SECCCA for more information

Table 01.

Key upgrades (beyond the minimum 6star NatHERS) and Costs

The following are the upgrades and outcomes of a 27 square house recently built in Officer. Please refer to the SECCCA Toolkit for further details of the key upgrades and rating systems.

NUMBER	KEY UPGRADES	TYPE OF ACTION	COST EXTRA	POINTS
1	Maximised orientation of living spaces north	Passive	$0 *modelled on average household use	1
2	An appropriate Shading Strategy (including eaves, awnings, pergolas, reducing window sizes, block out blinds etc)	Passive	$0 *modelled on average household use	1
3	Upgrade insulation in roof and walls	Building Fabric	$3850	1
4	Double Glazing	Building Fabric	$1500	1
5	Good – Excellent Air Tightness	Building Fabric	$300	1
6	Efficient Solar Hot Water or Heat Pump (ie. not a Water Tank)	Appliance	N/A	1
7	Fully Electric	Appliance	$1300	1
8	Efficient electric reverse cycle heating and cooling system	Appliance	$4000	1
9	Solar PV System	Generate Power	$5000	1
10	Battery Storage System	Store Power	$10,000	1
N/A	Less $500 in savings from no gas line install	N/A	-$500	
TOTAL POINTS			**$25,450**	**10**
PAYBACK: 6.7 YEARS*				
SAVINGS AFTER PAYBACK BETWEEN 6.7 AND 15 YEARS			**$23,812**	

*Notes: additional $4000 to met minimum 6 star requirement = Total $19,450. Assumes typical bill saving of $1602 annual electricity and gas $1267 annually. Total $1602 + $1267 saving = $2869 annual electricity and gas saving.

Additional upgrades:

- Internal sliding doors for controlled openings - lounge, passage and meals to rear passage $700
- Fans 3 bedrooms + 2 living area's @ $250 each

Table 02.

Energy Ratings and Power Bills

RATING / TEST / OUTCOMES	OUTCOME
NatHERS	7.3
Victorian Residential Efficiency Scorecard	10
Blower Door Test	3.65ACH50
Energy Bills	Electricity: $0 Gas: N/A

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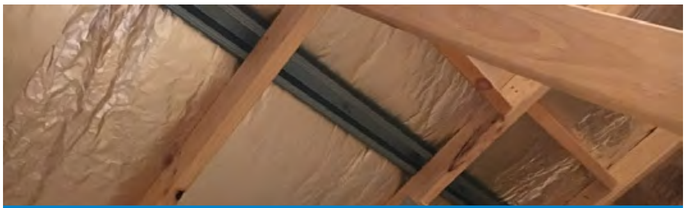
CASE STUDY ANALYSIS 05.



Anticon Blanket R1.3 under colorbond roof.
As well as assisting insulate the home it stops condensation and dust entering the roof space.

Sanden Heat Pump highly efficient alternative to Solar Hot Water

Reduced window size, good use of fans and complemented with reverse cycle split systems through the home for use when required.

Benefits

as reported by the homeowner:

- Better for the environment
- Small amount of initial outlay the running costs have decreased
- It's a no brainer, people say why wouldn't you have that
- Lot more comfortable living

Barriers

as reported by the homeowner:

- Just time, making sure the products and process could be replicated at minimal cost
- All of its easy to do, right down to draught sealing, caulking and taping
- We thought that lot of this sort of stuff was going to be too expensive. Workshops with SECCCA showed what would give us the most benefit for least cost
- A lot of misconception about what to do to achieve zero emissions

Conclusion

This house achieved 10 out of the 10 key recommendations through the program at a cost of $24,500. As a result the fully electric house was highly rated under the Residential Efficiency Scorecard and under NatHERS achieved a 7.3 star rating.

The home was air tight above recommendations and as a result may require forced ventilation in the future. As a result of the use of efficient appliances such as lights, hot water heating and heating and cooling coupled with solar and a battery system this house uses zero net electricity and exports power to the grid.

This house was used as a demonstration home for a local builder and demonstrates all the key recommendations at an affordable price. Excluding the battery system this house demonstrates that for an additional $15,000 an efficient, comfortable, zero energy is possible and affordable.

Good example of R5 roof insulation installed and as indicated in red circle a sealed extraction fan unit for use in bathrooms and toilets.

5kw Solar systems installed with excellent northern orientation

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NEW HOME ENERGY ADVISORY SERVICE

CASE STUDY ANALYSIS 06.

Case 06.

Occupants:
Three adults and two children

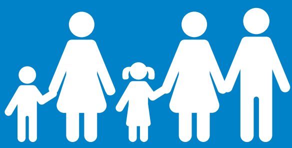

Table 01.

Key upgrades (beyond the minimum 6star NatHERS) and Costs

The following are the upgrades and outcomes of a 38 square double storey house recently built in Officer.
Please refer to the SECCCA Toolkit for further details of the key upgrades and rating systems

NUMBER	KEY UPGRADES	TYPE OF ACTION	COST EXTRA	POINTS
1	Maximised orientation of living spaces north	Passive	$0	1
2	An appropriate Shading Strategy (including eaves, awnings, pergolas, reducing window sizes, block out blinds etc)	Passive	$0	1
3	Upgrade insulation in roof and walls	Building Fabric	$1600	1
4	Double Glazing	Building Fabric	$10,000	1
5	Good – Excellent Air Tightness	Building Fabric	$0	1
6	Efficient Solar Hot Water or Heat Pump (ie. not a Water Tank)	Appliance	$0	1
7	Fully Electric	Appliance	$2500	1
8	Efficient electric reverse cycle heating and cooling system	Appliance	$3400	1
9	Solar PV System	Generate Power	Included (around $5000)	1
10	12.4 Battery Storage System	Store Power	Included (around $10,000)	1
	Deleted gas install -$500	N/A	-$500	
TOTAL POINTS			**$32,000**	**10**
PAYBACK: 9 YEARS*				
SAVINGS AFTER PAYBACK BETWEEN 9 AND 15 YEARS**			**$17,214**	

*Notes: additional $4000 to met minimum 6 star requirement = Total $26,000. Assumes typical bill saving of $1602 annual electricity and gas $1267 annually. Total $1602 + $1267 saving = $2869 annual electricity and gas saving.
**However note that these participants included the cost of these efficiency upgrades within their budget, foregoing other household upgrades. Therefore it can be argued that the payback returns are instant at $2869 per annum and $43,035 over the course of 15 years.

Additional upgrades:

- Dark tiles to absorb heat in the winter and light colours external – roof.
- Built with Hebel – however some foam in places.
  Plus sarking = R2 (but didn't put extra batts in the walls due to the Hebel, though we should have to bump it up further).
- Screenaway blinds – channel on sides.
  Just charged for panelling $5k in total ie. no real extra cost.
- $800 extra for the insulated panel garage door.
- Door in hall to zone top and bottom of the house – excellent at zoning the house.

Table 02.

Energy Ratings and Power Bills

RATING / TEST / OUTCOMES	OUTCOME
NatHERS	6.9
Victorian Residential Efficiency Scorecard	9
Blower Door Test	4.1ACH50
Energy Bills	Electricity: $50 - $100 a quarter Gas: N/A

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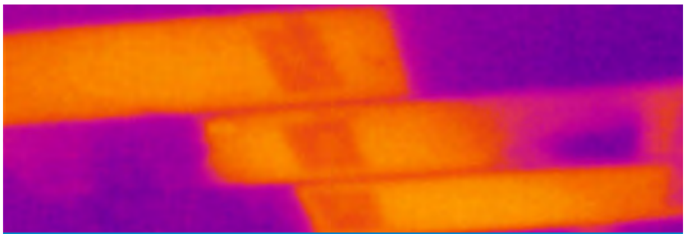
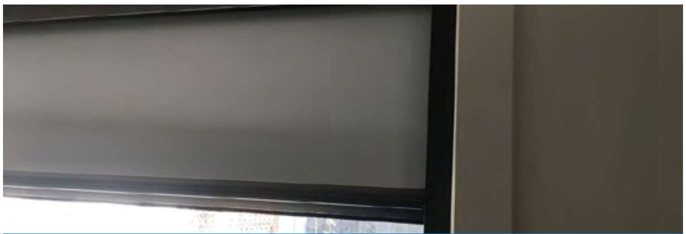
NEW HOME ENERGY ADVISORY SERVICE

CASE STUDY ANALYSIS 06.

A number of areas were identified that were missing insulation. These will be rectified by the builder.



The thermal inspection shows up missing insulation in the roof space.



In many rooms window sizes were reduced and screen away blinds installed to block radiant heat from the sun.

Benefits

as reported by the homeowner:

- Moved in in June, in winter didn't need to put the heater on. Only a couple times when family were down from Queensland
- Love the cooktop – so easy to use, heat is instant and easy to clean. Would never go back (to gas).
- Electricity – generating more than using. Bills about $50-100 a quarter. Most of that is the service fees. We use 14kw on average per day
- Was 24 - 28 degrees Celsius inside in winter while 14/18 degrees Celsius out. Just comfortable to live in all the time. Even when it's a bit hot, its not unbearable – not humid
- Don't hear any sounds outside from the double glazing – very quiet house

Barriers

as reported by the homeowner:

- Very disappointed with the builder, offer of the included battery and solar was a gimmick. Sales rep seemed to care, however at contract stage was very difficult to include energy efficiency aspirations. The actual delivery of the house was generally very poor and would never build with this builder again.

Conclusion

This house achieved 10 out of the 10 key recommendations through the program at a cost of $22,000 (excluding the battery system). As a result the house was highly rated 9 out of 10 under the Residential Efficiency Scorecard and with a NatHERS rating of 6.9.

The home was air tight within recommendations. As a result of the use of efficient appliances such as lights, hot water heating and heating and cooling coupled with solar this house uses zero net electricity.

No gas bills occur as the house is fully electric and when the power goes out due to the battery system they are able to keep basic lights and fridges on for quite some time. The occupants stated that they excluded other household features such as more expensive tiles and square set plaster corners to offset the costs of the energy efficiency upgrades. Therefore, by keeping it within budget the paybacks are instant.

Solar system facing north and eves effectively shading windows.

12.4kw Tesla Battery System with back up function to enable use during power outages.