A guide

Sustainable home renovations

Green Building Council Australia

Allianz

Building a sustainable future

Sustainable renovations guide

This practical guide is intended for use by homeowners and building practitioners seeking to improve the sustainable performance of existing residential homes, including as part of additions and alterations.

Improvement, design and technological strategies are divided into three key categories based on the Green Star Homes Standard; Positive category focusing on energy efficiency initiatives; Healthy category supporting the wellbeing of occupants; and Resilient category safeguarding homes and communities for the future.

Each section provides background rationale for the guidance, alongside quick wins and strategies to consider for major renovations. While every project and home presents its own set of challenges, it is intended that parts of this guide can be selected to address specific project aspirations and to improve a home over time. The advice in this guide is not intended to be fully comprehensive, it is a starting point for further investigation.

The final sections of this guide provide renovation case studies and commentary on the role of key stakeholders and financial considerations.

Green Building Council Australia

The Green Building Council of Australia (GBCA) was established in 2002 to lead the sustainable transformation of the built environment. Our vision is for healthy, resilient and positive places for people. GBCA represents more than 550 individual companies with a combined annual turnover of more than $46 billion. Members include major developers, professional services firms, banks, superannuation funds, product manufacturers, retailers, utilities and suppliers – and together they represent 50,000 people. We also work with 32 local government members, representing 26 per cent of Australia's population, 24 state government departments and land organisations, and 21 universities.

Allianz

Allianz Group is one of the world's largest insurers, providing support to over 100 million customers across 70 countries.

Allianz Australia has been supporting customers for over 100 years. As one of Australia's largest general insurers, more than 3 million customers trust Allianz with their insurance needs. Allianz insures around 25% of the top 200 ASX companies, making it one of the leading private workers compensation insurers in the country. Allianz is committed to securing the futures of customers and employees and uses its global and local experience toward tackling some of the most significant societal issues, including climate change and mental health.

FIGURE 1

The Cape, Core 9 home

SOURCE:
The Fifth Estate

PHOTO:
Leo Edwards

Thank you to our technical partner.

dsquared

Our vision is to think beyond the square.

Our mission is to reduce the impact on the environment of our client's actions by providing innovative solutions, challenging perceived thinking, and pushing the boundaries of achievement whilst using all resources in a sustainable way.

We confirm that all work has been undertaken in accordance with our ISO 9001 accredited quality management system.

The dsquared team wish to acknowledge the Traditional Custodians of all country throughout Australia, and their cultural, spiritual, physical, and emotional connection with their land, waters, and community. We pay our respects to all Elders past, present, and emerging.

greenstar

Green Star is an internationally recognised sustainability rating system for the built environment. Launched by GBCA in 2003, Green Star is Australia's largest voluntary and truly holistic voluntary rating system for buildings, fitouts and communities. Green Star assesses the sustainability attributes of a project through a range of impact categories. Project teams must demonstrate how their project meets credit criteria within each category to improve sustainability performance. This is assessed using Green Star's robust, transparent and independent assessment process and a certification awarded if enough credits are achieved. For more information on Green Star, please see Appendix A.

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1.0 Introduction

1. Australian Bureau of Statistics: Media Release. https://www.abs.gov.au/media-centre/media-releases/new-house-and-renovation-approvals-continue-rise-november
2. Department of Agriculture, Water and the Environment, "National Waste Report," 2020

Home renovations contribute significantly to the Australian economy. In the 12 months to October 2021, $11.82 billion worth of renovation approvals were given around Australia. This represents a 33% increase on levels in 2020.[1]

While supply chain issues have impacted construction timelines and costs in Australia and overseas, the trend towards home renovations is set to continue. The reasons for this are complex but include changing work and family dynamics following the Covid-19 pandemic, the expense of moving house, and investment in family homes as a financial asset.

Renovating an existing house rather than demolishing for a new build reduces waste and embodied energy. Construction and demolition activities produce about 44% of Australia's total waste, but this can be minimised by embedding sustainability into the design and construction using a standard like Green Star Homes.[2]

Green Star Homes is Australia's only independent sustainable homes certification tool. It was released by the Green Building Council of Australia (GBCA) in August 2021, following years of success with Green Star. Green Star was established in 2013 and has certified over 4000 buildings, fitouts and communities across Australia with the residential market being a natural next step.

The Green Star Homes standard seeks to create highly efficient, fossil fuel free homes, powered by renewables that are healthy and resilient for all Australians. The third-party certification provides assurance on the sustainability standard of buildings with the Green Star Homes Trademark.

Green Star Homes has three categories focussing on core outcomes that define what a healthy, resilient and positive home is. This guide aligns with the Green Star Homes standard to provide practical opportunities for home renovations.

The Green Star Homes standard applies to new volume home construction, however there are key attributes that can be implemented on minor or major renovations to help a home achieve improved outcomes across energy efficiency, health, and resilience. Building on the standard, the purpose of this document is to provide a guide for home renovations, for industry practitioners and homeowners.

Insurance: Allianz has partnered with GBCA on this guide because property insurance is an important part of home ownership. Insurance helps to protect property owners from the financial impact of loss or damage to their insured assets. It is important to increase investment in building resilience in our homes and communities and at the same time address the primary cause of climate change by reducing greenhouse gas emissions. Allianz aims to help Australians' homes be future-ready. This guide provides information on how we can do this together through sustainable renovations.

For over a hundred years, Allianz has been helping Australians secure their future. Allianz is committed to playing our part in tackling climate change; supporting the transition to net zero Greenhouse Gas (GHG) emissions, managing climate change risk and reducing our own environmental footprint in our business. Allianz believes that it has an important role to play in transitioning the economy and our communities to net zero GHG emissions and in helping Australians better protect themselves against climate change.

In 2022, Allianz processed over 90,000 Home Insurance claims, that included repair or rebuild of the insured building as part of the claim. Many property claims may provide an opportunity for the industry to consider how best to assist customers to rebuild in a more resilient and sustainable way.

1.1 Housing typologies

3. Australian Bureau of Statistics: Housing. https://www.abs.gov.au/statistics/people/housing/housing-census/2021

Several different house types exist within Australia which can be categorised into three distinct groups; single detached houses; semi-detached houses (or townhouses) that share a common wall; and apartments. In 2021, there were 10,852,208 private dwellings in Australia, of which 70 per cent were separate detached houses, 13 per cent were semi-detached townhouses and 16 per cent were apartments.[3] Given that apartment renovations have implications with governance, such as STRATA, the focus of this practical guide will be on single houses and townhouses, however some guidance may still be applicable to apartments and is identified with the apartments logo below shown alongside relevant sections.

FIGURE 2

Housing typologies in Australia

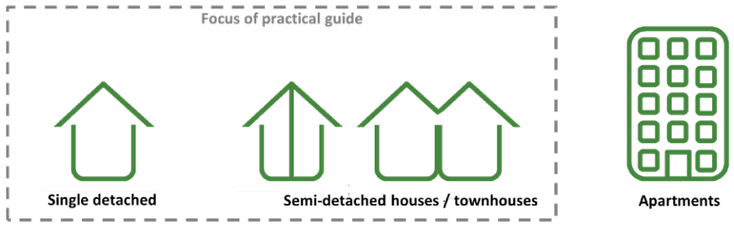


FIGURE 3

Green Star Homes categories and description

SOURCE: Green Building Council of Australia (GBCA)

POSITIVE

Fully electric, draught sealed, efficient, and powered by renewables

HEALTHY

Ventilated, comfortable and with products that are better for you

RESILIENT

Water efficient and climate change ready

2.0 Energy efficient homes

POSITIVE

4. The Commercial Buildings Energy Consumption Baseline Study 2022
5. 2021 Residential Baseline Study for Australia and New Zealand for 2000 — 2040
6. Department of Energy and Science, "Residential Energy Baseline Study: Australia," 2015.

A positive, energy efficient home saves money through lower energy bills, is comfortable and has an additional benefit, in that it is designed to produce renewable energy that is equal to most of its energy consumption over 12 months of its operations.

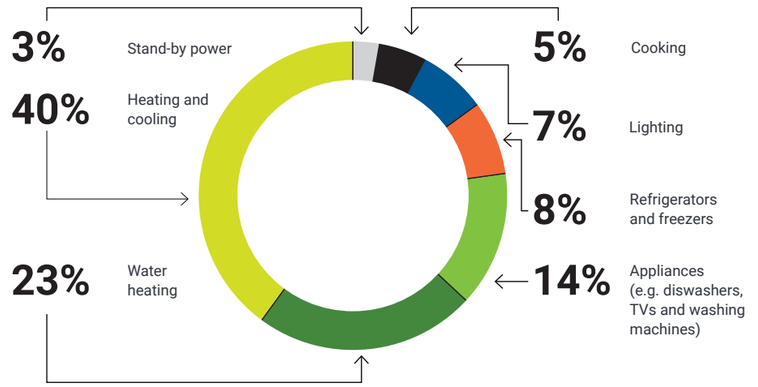
53%[4] of Australia's total built environment emissions come from our homes[5]. Most energy is used to heat and cool homes, with the majority going to the heating of homes during winter. Water heating is the next highest consumer of energy, followed by appliances, lighting, cooking and lastly stand-by power. The figure below shows the average energy use across Australian homes.

The following section outlines approaches to improve energy efficiency of homes through renovation activities.

FIGURE 4

Residential baseline study for Australia 2000-2030[6]

SOURCE: Green Star Homes tandard, Green Building Council of Australia (GBCA)



2.1 Thermal performance

The cornerstone of energy efficiency and thermal performance in any home is understanding the principles of Passive Design, in which the building or home design responds to the local climate to maintain comfortable temperatures internally. There are four key aspects in understanding Passive Design:

1. **Orientation:** The direction in which the home and in particular windows are located can be optimised to work with the sun path to utilise passive solar energy. The sun travels through the northern part of the sky, rising in the east and setting in the west and is lower in the winter and higher in the summer, which can be harnessed over the seasons to provide free heating (in winter) and reduce overheating (in summer).
2. **Insulation:** When the building envelope (external walls, roof and floors) are fitted with insulation, this inhibits the transfer of heat both into and out of the home. This means that your heater or air conditioner will run more efficiently, or might not be required at all, to maintain comfortable indoor temperatures.
3. **Thermal mass:** Heavy, dense building elements such as concrete and brick have a 'Thermal Mass', which means they absorb heat energy. This energy is stored and released at a later time, known as a 'Thermal Lag'. In summer thermal mass elements will absorb heat, keeping the home cooler during the day, and release that energy at night-time when evening breezes can purge the home of built-up heat. In winter, heat released at night will help to warm the home as temperatures lower.
4. **Glazing:** Windows are an important element in your home. Whilst providing light, views and ventilation, they can also be a significant source of heat loss during winter and of unwanted heat gain during summer. Careful consideration of the size of the windows as well as the orientation is crucial to passive design and to achieve an agreeable balance between amenity and comfort. Double glazing also provides additional strength which protects against breakages, noise and increase fire resistance.

FIGURE 5 & 6

Sun movement from high angle in summer to low-angle in winter

SOURCE: Your Home

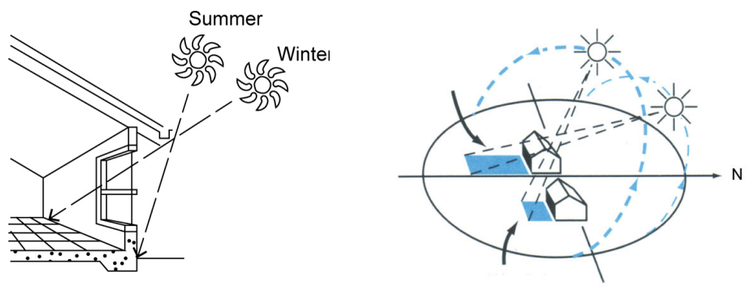


FIGURE 7

Windows facing north allow free heating from low-angle winter sun

SOURCE: Your Home[7]

7. Your Home: Australia's Guide to Environmentally Sustainable Homes," Australian Government, https://www.yourhome.gov.au

Whilst passive design strategies can be difficult to implement in existing homes, a major renovation or addition can be a good time to consider how the geometry and layout can be improved to create a more efficient and thermally comfortable home. Maximising north facing windows to new areas is a priority. If scope allows, it is worth exploring opportunities to improve existing areas too, by relocating windows to different walls or reducing window sizes.

Ventilation can also be optimised when changes to the house geometry and window placement are being undertaken. Narrow and open plan layouts best facilitate cross ventilation with operable window placement on opposing walls. Also consider the direction of prevailing breezes for the specific location and if it is possible to arrange windows to harness these.

High level operable windows support passive convection, allowing rising heat to escape, which is particularly effective when coupled with low level windows. The window type can also optimise ventilation, where louvres and sliding doors or windows maximise access to fresh air, awning windows will provide less, and large expanses of fixed windows should be avoided.

FIGURE 8

Diagram of cross-ventilation in floorplan

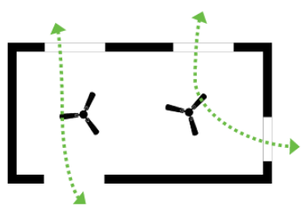
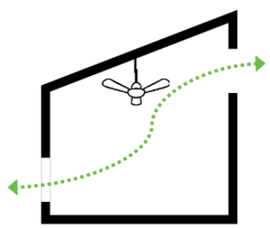


FIGURE 9

Diagram of convection ventilation in section with high-level and low-level operable windows



Ceiling fans are also an inexpensive way to facilitate better ventilation in your home. Multidirectional airflow fans can operate in both directions (clockwise and anti-clockwise), which means in winter the fan will push rising heat back down towards the occupied part of the room.

Insulation is fundamental for good thermal performance and associated energy efficiency, and is an easy way to immediately improve the comfort of an existing home. Whilst current building standards require minimum levels of insulation to be included in the roof, walls and floors for new homes and new construction (i.e. additions), many older homes may not include any insulation at all. Also, insulation often degrades over time or may 'sag' in the wall cavity, losing its effectiveness. Therefore, it is good practice to install new insulation wherever there is access. Similarly, it can be worth checking the installation of existing ceiling insulation to ensure there are no gaps, as insulation is most effective when in a continuous layer.

Ceilings typically have the most impact and are readily accessible from an access hatch into the attic space. Walls can be difficult to access, however where internal or external linings are removed and replaced, insulation can be added in. There are also options for blow-in insulation products that can be used to fill-in a wall cavity, such as in double brick or brick veneer construction, however these solutions are typically at a higher cost. It is also important to ensure these products are hydrophobic to mitigate the risk of mould from condensation. In homes with suspended timber floors, installing underfloor insulation can have a substantial improvement on the thermal comfort, particularly in colder regions.

Not all insulation is created equally and there are varying levels of insulation effectiveness, which are expressed as R-Values. An R-Value is the measure of the product's level of resistance to heat transmission and the higher the value the more effective the insulation product will be at preventing the movement of heat into and out of the home. The following provides a guide on typical R-Values of added insulation for each building element:

FIGURE 10

Recommended insulation R-Values per building element

FIGURE 11

Insulation in stud walls

SOURCE: Earthwool

Shading strategies are a simple and cost-effective way to improve the energy efficiency of any home and reduce energy consumption from air conditioning. New construction can consider permanent fixed shading such as canopies and eaves.

As a rule of thumb, shading depth should be 45% of the height from the bottom windowsill to the bottom of the horizontal shade for colder and temperate climates (zones 3-7). For hot climates (zones 1 and 2) this should increase to 50% or more (refer section 8.1).

Quick wins

- Retrofit ceiling insulation, R4.0 or higher.
- Install external shading, such as roller blinds, to problematic windows that emit summer sun, particularly on the east and west.
- Install ceiling fans with multi-directional airflow.

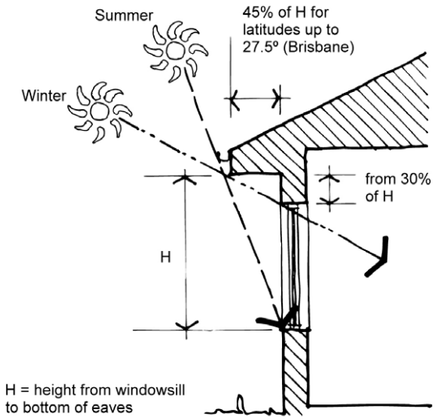
Major renovations

- Consider the geometry and layout, ensuring main living areas and windows face north where practical.
- Minimise glazing to all orientations except north.
- Install insulation to walls, roof and suspended floors in all new construction and wherever there is access in existing fabric.
- Include shading or eaves into the design of new construction to restrict summer sun.
- Consider inclusion of thermal mass elements such as Concrete Slab on Ground or feature masonry internal walls.

7. Your Home: Australia's Guide to Environmentally Sustainable Homes," Australian Government, https://www.yourhome.gov.au

FIGURE 12

Shading depth rule of thumb[7]



Where fixed shading strategies are not possible, for example on existing windows, external canvas roller blinds or roller shutters provide a good inexpensive solution. Blinds and shutters work particularly well on east and west facing glazing which needs to be shaded vertically for best results in blocking low sun angles in the morning and afternoon. External louvres are also an option. The adaptability of these types of external shading strategies allow for the best of both worlds, as they can be fully opened to allow winter sun into the home for passive heating, whilst still restricting uncomfortable summer sun. Shading is of particular importance in the hotter climate regions.

Thermal Mass is another strategy that can be considered to improve thermal performance of a home. For any new construction as part of an addition, a concrete slab (on ground) will outperform a suspended timber floor and is recommended wherever practical. Other ways to incorporate thermal mass elements are through internal feature brick or stone walls or reverse brick veneer construction.

It is important that massing elements are within an insulated external envelope (external walls), as massing elements externally will not perform in the same way. Thermal mass strategies can be tricky to get just right, as too much mass can result in very cold or hot homes, depending on location. Getting advice from a thermal assessor or sustainable designer/architect, could assist in determining if this is a worthwhile strategy.

2.2 Window system

7. Your Home: Australia's Guide to Environmentally Sustainable Homes," Australian Government, https://www.yourhome.gov.au

Glazed windows and doors offer great amenity to any home, providing views and light to interior spaces, whilst also providing fresh air and a connection to the outside. However, these elements can also be a major source of heat loss and unwanted heat gain. Up to 40% of a home's heating energy can be lost and up to 87% of its heat gained through windows.[7] Therefore, glazed windows and doors are crucial to the thermal performance and energy efficiency of a home and provide an opportunity for improvement during a renovation.

There are many factors to consider when selecting new or replacement glazed windows and doors. A lower U-Value will be beneficial for all climate zones. Through the combined effect of having double glazing, low-e coatings and insulated frame materials, a lower U-Value can be achieved. Although they represent typical practice in Australia, standard single glazed windows offer very little benefit to thermal comfort and are large holes in the insulating envelope of the home. Wherever budget allows, aiming for increased glazing performance is recommended.

Installing double glazing will help improve a home's resilience to a changing climate. The increased strength of the glazing also allows for longevity, where the window will be more protected against breakage and have increased fire resistance, whilst also reducing noise transfer from outside.

Another element to consider is the window framing. Aluminium and steel framed windows are most common however allow greater conductance through the frame and have higher U-Value when compared to thermally broken frames, including timber and uPVC framing.

uPVC framing is relatively new to Australia but is the most widely used window frame in Europe and the US due to the superior thermal performance and physical durability. Resistant to mould and moisture, unaffected by salt corrosion and UV, uPVC is long lasting, won't fade and is low maintenance.

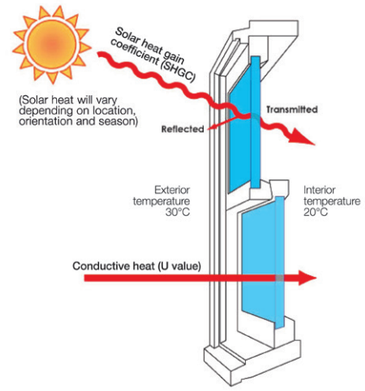
Window selection also needs to consider the specific location and climate with respect to heat gain. Hot climates should always aim for a low SHGC (below 0.5) as these are cooling dominated regions, whereas temperate and cold climates benefit from a high SHGC (above 0.5) being heating dominated areas. However careful window placement and shading will need to be considered alongside SHGC in temperate climate regions, to ensure they are protected from direct summer sun to avoid overheating.

When replacing existing windows consider the placement and size. Windows that emit too much heat, particularly those facing east and west that make a room hot and uncomfortable, or larger expanses of glazed area in colder climate regions that result in significant heat loss, can be reconfigured to improve comfort and efficiency. Using creative design with additional framing and cladding, windows can be reduced in size or moved, as seen in the Light House Architecture example for the '**Fab-ode**' project below.

FIGURE 13

Key Properties of Glass

SOURCE: Your Home[7]



The science

Glazed products are provided with performance ratings through the Window Energy Rating Scheme (WERS), allowing consumers to compare options and suitability for their climate region. Performance is represented in two key metrics:

U-Value – measure of the insulating ability of the unit, or the amount of heat conducted through the window/door. The lower the value, the greater resistance to heat flow.

SHGC – The Solar Heat Gain Coefficient expresses how readily heat from direct sunlight flows through the window/door, in a value between 0 and 1. The less heat transmitted, the lower the number.

These values are provided for both glass only, as well as whole-of-system values for glass and framing combined. When selecting a product, the whole-of-system performance should be used for a fair comparison.

FIGURE 14

Secondary glazing

FIGURE 15

Heavy curtain with pelmet

Improvements are also possible without completely replacing windows with new. Installing secondary glazing, which adds an additional pane of glass over the existing window, simulates the impact of double glazing, improving the U-Value and insulation performance of the window. Other options also include adding tinting and Low-Emissivity (Low-E) films or liners to the existing glass, which can be installed as an affordable DIY solution and be a simple option for hotter climate areas.

Window furnishings, such as internal blinds and curtains, are an inexpensive solution to improve the thermal performance of an existing window system and reduce convective heat transfer through the window. Heavy fabrics and multiple layers provide an insulating affect. This benefit is improved if air movement behind the curtain is reduced by closing off the gap between the curtain and window or wall at the top, such as with a pelmet or bulkhead.

FIGURE 16

Reconfigured existing window

SOURCE: Light House Architecture 'Fab-ode'

2.3 Airtightness

FIGURE 17

External wall wrap

SOURCE: Team Green Architects

Uncontrolled air movement into a home can occur through gaps in the building construction, missing or poor seals around windows and doors, fireplaces and unsealed vents. This unintentional air movement is estimated to cause 25% of winter heat loss[8], leading to increased energy consumption from heaters. Draught-proofing a home through increased airtightness can be a simple strategy to improve the thermal comfort, energy efficiency and acoustics. The following section provides common areas of air leakage and possible rectification activities.

8. CSIRO, "House Energy Efficiency Inspections Project," 2015

External doors:
Ensure doors are fitted with bottom weather seals, such as sweep seals. Apply adhesive foam or rubber strip seals to the sides and top of the door jamb.

Windows
Reapply damaged silicon seals around glazing in existing windows. Apply adhesive foam or rubber strip seals to all sides of openable window areas where possible, such as around awning windows. Apply caulking around window architraves to seal small gaps between architrave and wall. Note: Weep Holes and drainage ducts should never be covered as it may cause rainwater to enter the home. Retrofitting windows should be appropriately flashed to control water movement.

Exhaust fans
Retrofit automatic draft stoppers over existing exhaust fans and ensure all new exhaust fans include backdraft damper to restrict airflow when not in use.

Vents
Permanent vents in ceilings and walls should be completely sealed over unless required to provide ventilation for moisture or un-flued gas heaters, which are recommended to be avoided. Vents in bathrooms can be replaced with exhaust fans that include dampers. Ducted evaporative cooling vents are a significant source of heat loss in winter, so ensure the vents are closed up for the season and for greater sealing fit with duct covers.

Lighting
Recessed lighting such as downlights should be appropriately rated (IC4 or ICF) sealed LED fittings with insulation covering over the top in the roof space.

Open fireplaces
Existing open fireplaces are a significant source of air leakage as they are typically not sealed at all from the outside and draw in large volumes of air. Consider retrofitting opening with electric fireplace or sealing up completely, either by covering over and sealing opening or with a chimney balloon. Installing damper flaps are also an option if fireplaces are to be kept operational.

Building construction
Ensure junctions and gaps in between building components are sealed with durable, flexible caulking, or for large gaps expandable foam, however, use caution about covering weepholes in brickwork as these are designed to allow for ventilation and water drainage. Existing raised timber flooring can be refinished and sealed or covered with tight fitting floor coverings and underlay. New constructions are recommended to include vapour permeable membranes within wall and roof constructions, effectively taped at joins and junctions, to create an air-tight barrier.

8. CSIRO, "House Energy Efficiency Inspections Project," 2015
9. Sustainability Victoria, "Energy Efficiency Upgrade Potential of Existing Victorian Houses," 2015.

To test and identify air leakage in new and existing construction, a qualified professional can be engaged to undertake a Blower Door Test. The test entails a large fan fitted to an external door that measures airflow into and out of the building as it is pressurised and depressurised. During the test, points of air leakage and infiltration can be identified by feeling airflow at poorly sealed junctions between building components or by identification methods such as smoke pens. The result of this test will enable builders and homeowners to understand instances of uncontrolled air movement that would benefit from the above rectification activities.

Existing homes can have a typical air leakage rate of as high as 40m³/hr·m³@50Pa[9] (see note), whereas new construction in Australia is around 15.4m³/hr·m³@50Pa.[8] The table below provides best practice air permeability targets by location. It is not recommended that homes have an air permeability of less than 2.0 m³/hr·m² @50Pa without proper consideration for ventilation as very low air leakage rates cause implications with condensation and moisture, refer section 3.1.2.

Climate zone	Example locations	Air permeability target (m³/hr·m³@50Pa)
Zone 1-4 and Zone 6	Cairns, Darwin, Broome, Brisbane, Byron Bay, Alice Springs, Mt Isa, Sydney East, Perth, Wagga Wagga	≤ 7.0
Zone 5 and Zone 7-8	Adelaide, Melbourne, Sydney West, Canberra, Hobart	≤ 5.0

Note: Air changes per hour (ACH50) and air permeability (4m³/hr·m³@50Pa) have been used interchangeably to provide a consistent metric, as per AIRAH report.[22w]

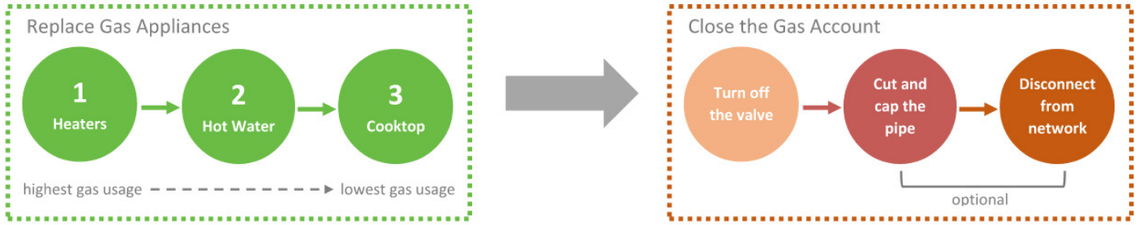
FIGURE 18
Blower door test fan fitted into entrance door
SOURCE: Climasure

2.4 Transition from gas

Extracting and burning gas creates greenhouse gases that contribute to climate change. Gas is a fossil fuel, in which the main component is methane, a greenhouse gas nearly 100 times more potent than carbon dioxide in the short term.[10]

Gas use within our homes also risks health and wellbeing. Cooking with gas is estimated to be responsible for up to 12% of the burden of childhood asthma in Australia. A child living with gas cooking in the home faces a comparable risk of asthma to a child living with household cigarette smoke.[11] Whilst selected air purifiers with HEPA and activated carbon filters may offer some benefit, they will not completely remove the health risk and will need to be operated continuously to be effective, increasing energy consumption.

With respect to climate change and human health, it is recommended that all renovation activities make decisions that support divestment from gas. An all-electric home will also benefit homeowners financially by removing the fixed gas supply charge, which is around $1 per day and future proof the home against a decarbonising environment. The following flow chart provides a guide on the process to transition from gas to an all-electric home.



Replace the appliance that uses the most gas first, which in most cases will be space heaters or a hot water service. These will attract a larger upfront investment, however will also provide the greatest operational cost saving with efficient electric alternatives, which will assist in funding the next appliance swap. Online tools can assist in calculating savings and planning the financial investment over time. Refer to 'Make the Switch' resource in section 8.1.

Gas cooking is often the last barrier to complete electrification however induction cooking is more than twice as energy efficient as gas, boils water in about a third of the time, responds instantly to changes, is easy to clean and has no fumes or open flame, which means it is safer. The digital controls also allow for additional safety features like child locks and automatic cut-off for cooking when no pot is detected, which means the appliance cannot be activated if there is nothing to cook. However, induction cooktops will require specific pots and pans, the rule of thumb is if a magnet sticks to the bottom of the pot then it will likely work.[9]

Replacing gas stoves and ovens with an electric and induction alternative will require a gasfitter to disconnect and cap off the gas supply to remove the existing appliance(s).

10. Climate Council, "Kicking the Gas Habit: How Gas is Harming our Health," 2021.
11. C. C. A. Region, "Make the Switch," https://maketheswitch.org.au/how-to-switch/ [Accessed 2022]

FIGURE 19

Induction cooktop

SOURCE: MIELE

A new power supply may also need to be installed by an electrician for the new appliance if there is not one already. If the current cooktop is fitted within the cabinetry (rather than free standing), be sure to select a new appliance that will fit within the current cutout or space.

Once the home has no gas appliances, contact the energy retailer and request the following:

- A final meter reading
- To close the account
- To close the stopcock or service shut-off valve

Someone from the retailer will physically visit the property to read the meter and close the valve. Closing the valve will prevent gas flowing through the meter which will instigate the account to be reopened. Disconnection from gas infrastructure attracts a fee from the distributor which is passed on to the customer by the energy retailer and varies by location. The Canstar Blue website provides a summary of approximate disconnection costs by state and distribution network, refer to resources in section 8.1.

There is no need to go any further in your transition from gas, however to ensure there are no unintended gas leaks you can opt to engage a gasfitter to cut and cap the pipe from the meter to your house, isolating the property from the network. Going a step further, the gas connection can be decommissioned by removing the meter and digging up the pipe that connects the property to the mains pipework in the street. However, this is unnecessary, closing the stopcock and the account is sufficient.

2.5 Energy efficient appliances

When selecting new appliances, energy consumption can be compared using the Australian Government's Energy Rating Scheme. Appliances sold in Australia are required to disclose estimated annual energy consumption for the product and are given a star rating for easy comparison. This information is displayed on a label visually present on the product but can also be found online at energyrating.gov.au, where product ratings can be compared.

Air conditioning systems are given two star ratings, to indicate heating and cooling efficiency separately. They may also use a Zoned Energy Rating Label (ZERL) which incorporates climate region contributing factors, including air temperature, water temperature, frosting, humidity, cloud cover, and adjusts the star rating accordingly. It is important to consider the climate region and prioritise efficiency of the system in response to whether heating or cooling is more dominate.

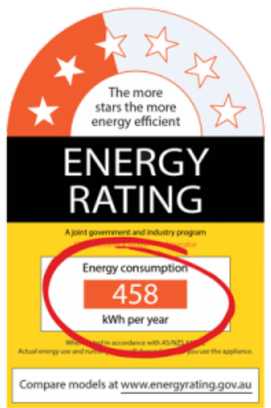
Recommended minimum star ratings for common appliance types and air conditioning are listed alongside as a guide. For more specific star rating recommendations for air conditioning based on system size and location, refer to Appendix A.

Appliance	Minimum Energy Star Rating
Refrigerator	4.5
Washing machine	4.5
Dishwasher	4.0
Dryer	6.0
Cooktop	All electric
Oven	All electric

FIGURE 20

Example Energy Rating label

SOURCE: Energy Rating



2.6 Hot water

12. (DCCEE), Department of Climate Change and Energy Efficiency;, "Regulation impact statement: for decision phasing out greenhouse-intensive water heaters in Australian homes. National Framework for Energy Efficiency," 2010

Hot water systems are the second highest use of energy in Australian homes. In Australia, about 48% of the energy used for water heating comes from natural gas, 45% from electricity, 3% from liquefied petroleum gas (LPG) and 4% from solar.[12]

To reduce energy consumption from hot water, some simple actions can be taken, such as reducing hot water consumption through installation of efficient showerheads and taps (refer section 4.1.1) or where possible turning down the thermostat on your hot water system.

Old electric storage hot water systems are very inefficient and should be considered for replacement. Recommended options include efficient electric heat pumps and solar electric boosted systems, which may also be eligible for financial rebates (refer section 7.1).

Heat pump water heaters absorb warmth from the air and transfer it to heat water. Hence, they are also referred to as 'air-source' heat pumps. They operate on electricity but are roughly three times more efficient than a conventional electric resistance water heater. The efficiency of a heat pump is expressed as a Coefficient of Performance (COP), indicating the kW of heat energy it can produce from 1kW of electricity supplied. Therefore, the higher the COP, the more efficient the water heater will be, providing a sound metric to compare products. It is recommended to aim for a **heat pump with a COP of 4.0.**

It is also important to consider the global warming potential (GWP) of the refrigerant in the heat pump hot water system, the lower the GWP, the less harmful the refrigerant may be in the event of leakage and at end of life. **Refrigerants should have a GWP of 10 or less.**

2.7 Renewable energy

Australia has amongst the highest residential solar uptake in the world on a per capita basis, with over 1.7 million homes having installed solar PV.[13] With solar panel efficiency increasing and prices on the way down (since 2008 the cost of solar PV has dropped by 80%)[14] installing solar is an important way of reducing energy bills and future proofing a home.

A Clean Energy Council Approved Solar Retailer can provide the best advice on a suitable system for the location, roof orientation and structural capability for additional weight, overshadowing, house size and energy consumption, and provide a certified contractor for installation. Refer to resources in section 8.1. In order to balance a home's predicted energy use over the year, solar PV system sizing based on the area of the home is provided alongside.

Battery storage systems are also an option to make best use of generated solar energy, limiting export to the grid. They can also help to future proof the home providing uninterrupted power supply during outages as a result of some extreme weather events. Assess the homes energy needs before investing in a battery system and consider the financial impact. Batteries will reduce your energy bill and are rapidly decreasing in cost, even faster than Solar PV over the last decade.[15] Government incentives may also be in place and as the price of energy continues to climb, if the opportunity to install a battery is available as part of a renovation, then it is a worthwhile investment.

If batteries are unable to be installed, the solar system should be future proofed by being 'battery ready'. This means that the system includes an inverter that is capable of routing direct current (DC) electricity generated by the solar panels into the battery for charging, in addition to converting DC in alternating current (AC) electricity for use within the home. This is an important distinction as most inverters are not able to perform this function. The inverter will also need to be placed in a suitable location and be coupled with the right hardware to enable batteries to be added at a later date. A 'battery ready' system will have a bidirectional metering device to optimise production and consumption and interface with the household's internet connection for tracking applications.

Installing solar PV, home battery storage or an electrical vehicle car charger will be possible with single phase power supply. However, upgrading to a 3-phase power supply will allow greater solar energy export to the grid and faster charging of multiple electric vehicles. To upgrade the power supply a registered electrician will need to be engaged to make an application to the energy distributor, who will perform a technical assessment and inspect the property. 3-phase power is not available in all areas and alterations to the power supply are performed by the energy distributor.

An alternative option for all homes including apartments in sourcing renewable energy may be to purchase GreenPower through the electricity retailer. GreenPower is renewable energy from government accredited sources. Almost all electricity retailers in Australia have a GreenPower Accredited product that lets you purchase between 10 and 100% of your electricity from a renewable source. The scheme supports the grid transition to renewable energy, with the cost of GreenPower invested into renewable energy projects within Australia. Since 2011, almost $500 million has been invested back to renewable energy generators through GreenPower purchases.

13. ARENAWIRE, "Australia's most renewable suburbs," 2017. https://arena.gov.au/blog/australias-most-renewable-suburbs/
14. Government of South Australia Department for Environement and Water, EnergySmart South Australia: The 10 Step Guide to Reducing Your Energy Bills, 2017
15. Rewiring Australia, "Castles & Cars: Savings in the Suburbs through Electrifying Everything," 2021

Quick wins

- Turn down the thermostat on your hot water service (if possible) to around 50 °C.
- Switch to water efficient showerheads and taps and take shorter showers.
- Switch to GreenPower as part of your energy contract.
- Replace old inefficient appliances.
- Use smart plugs to track consumption of major appliances.

Major renovations

- Replace hot water service for efficient Electric Heat Pump or Solar Electric Boosted System (avoid gas or gas boosted system).
- Select efficient ALL-electric appliances and air conditioning (refer star rating guide), including induction cooktop, avoid gas ovens and stoves.
- Remove and/or replace gas heating appliances with electric alternative.
- Consider installing Solar PV and battery storage.

FIGURE 21

Rooftop solar PV

SOURCE: ABC News

House floor area	PV system size (kWe peak)
Up to 150 m²	5.5
150 m² - 250 m²	7.5
250 m² - 350 m²	10

2.8 Metering and energy management

Utilising metering and monitoring devices allows homeowners to take control of their energy consumption by providing greater transparency on peak times of electricity use and identifying high energy use appliances. Tracking consumption has never been easier with smart phone applications and Wi-Fi, offering an array of inexpensive solutions through to full home automation setups. Some options also allow for Solar PV generation to be integrated, as well as controlling renewable energy export to the grid and appliance time-of-use against energy tariffs, to reduce energy bills and make best use of renewable energy generated. The following section provides a brief summary of potential options.

Smart plugs
Monitoring a home's energy use can be achieved simply by installing inexpensive adapter plugs for any standard power point enabled with WIFI that is connected to a mobile app. Allowing real time energy consumption to be tracked to the power outlet. Even just one smart plug could be moved around to different appliances to gain an understanding of high energy consuption.

Smart meters
Existing meters can be upgraded to smart meters by the energy retailer at cost. Digitally measuring whole-of-house energy use and remotely sending information to the energy retailer. Some providers make this information available to homeowners through web portals, apps or even in-home displays.

Energy monitors
Devices such as Powerpal or Emerald Electricity Advisor allow existing retail meters to simulate smart meters, utilising the pulse light on your meter to track real time electricity usage to a connected app. Currently available to Victorian households for free as part of the Victorian Government Energy Upgrades Scheme (VEU).

Home automation
Permanent hardwired solutions installed by a qualified electrician such as Clipsal Wiser and C-Bus, offering similar automation and energy tracking that can be achieved with a selection of quality smart plugs.

3.0 Healthy homes

HEALTHY

16. S. Brown, "Beating the $12 Billion Cost of Polluted Air," CSIRO, 1998. [Online]. Available: https://www.healthyinteriors.com.au/articles/indoor-air-articles/csiro-media-release-beating-the-12-billion-cost-of-polluted-air-s-brown-1998/
17. U. EPA, "'EPA's Approach & Progress' in Targeting Indoor Air Pollution.," 1993

The impact our homes have on us physically is significant. We spend 90% of our time indoors with two thirds of this being at home. Our homes, and where they are located, influences every aspect of our lives. There is an increasing body of work establishing the links between housing and an individual's health and wellbeing.

The CSIRO estimates that the cost of poor indoor air quality in Australia may be as high as $12 billion per year[16] and comparative risk studies performed by the US EPA and its Science Advisory Board have consistently ranked indoor air pollution among the top five environmental risks to public health. Further to this, indoor levels of many pollutants may be 2-5 times higher than outdoor air.[17]

Higher use of air conditioning, poor ventilation, and issues such as mould can negatively impact health conditions for occupants and may ultimately lead to ongoing medical issues. Well-designed homes give residents plenty of fresh air and daylight, while avoiding the build-up of moisture and harmful emissions from the materials used in construction, providing a healthier home.

The following section outlines approaches in renovation activities aimed at ensuring a home reduces these negative health impacts for those living within.

Wet areas
Mould, mildew, odours and microbial pathogens

Pets
Animal hair dust and dander, dirt, biological pollutants and odours

Building finishes, joinery and furnishings
VOCs from paint, varnishes, cabinetry upholstery furniture and carpet. Dust mites in Bedsheets

Products
VOCs from cleaning products, solvents and personal hygiene/beauty products such as aerosols and nail polish

Combustion
Cooking devices that use gas and fuel oil, heaters including woodburning fireplaces, gas and oil

Lack of ventilation
Air conditioning units that only recirculate air and do not remove pathogens. Fixed or closed windows (no fresh air)

Smoke
Tobacco smoke, including third hand smoke present in furnishings, clothes and building fabric

Outdoor air
Particulate matters, pathogens, VOCs, odours, pesticides, pollen and emissions (i.e., transport)

3.1 Air quality

FIGURE 22

Sources of indoor pollutants

Homes require constant circulation of fresh air to remove moisture, odours, and other pollutants to create a healthier indoor environment. Pollutants and dust can be carried indoors on footwear and get trapped in carpets, which may be a direct problem for crawling babies and young children playing on the floor. Regular cleaning and maintenance is an important first step to improve indoor air quality. The following section provides strategies to improve indoor air quality.

Cleaning and maintenance

Provide walk-off entry mats and regularly clean or establish a 'shoe-free' household. Ensure filters on exhaust fans and rangehoods, as well as air conditioning ducts are regularly cleaned, to avoid pollutants being recirculated. Don't let dust build up and consider installing hard floors in place of carpets.

Extraction

Ensure exhaust fans are installed in bathrooms and kitchens to reduce the build-up of moisture that can lead to mould. Laundries used for drying clothes, particularly with a condensing dryer, should also be fitted with an exhaust fan or ensure a window is open during operation.

Combustion

The exhaust from conventional petrol and diesel engines contains many pollutants, including millions of very fine particles and a variety of toxic gases. Where garages are attached to homes the connecting door should be weather-stripped and sealed on all sides to restrict contaminated air entering the home. Similarly, gas and wood heaters can be a major source of fine combustion particles and gas leaks. Ensure these heaters are well sealed, flued to the outside and regularly maintained or avoid using altogether.

Windows

Open windows to introduce fresh air and flush out pollutants. This will depend on the climate and the weather, and a balance will need to be achieved between the need to introduce fresh air, maintaining comfortable room temperatures, and conserving energy. Air conditioning systems only recirculate air and do not remove pollutants. Also remember to close windows when outdoor air quality is poor, such as during the presence of bushfire smoke.

Renovation activities

Renovation activities can expose building dust and harmful materials, such as asbestos and lead. Manage these through safe work practices and consider getting a building inspection prior to any renovation activities and stay offsite for duration of works.

Mechanical ventilation with heat recovery (MVHR)

Consider installation of MVHR to supply a constant source of fresh air where a high level of air tightness has already been achieved. Introducing fresh air is especially important when increasing the home's airtightness through building sealing activities, which can lead to unintended consequences such as condensation, mould and high internal levels of carbon dioxide, if not sufficiently ventilated. Opening windows can be sufficient, however a set-and-forget approach could be to install a MVHR system – refer below for more information.

Mechanical Ventilation with Heat Recovery (MVHR) provides a constant source of filtered outdoor air, whilst extracting stale warm air. It works by recovering (extracting) the thermal energy from the warm air within the building and using this to precondition the outside fresh air as it is drawn into the building. These systems are designed to operate continuously, while consuming very little energy and is separate from the air conditioning system. It is important to consider air tightness in planning for this system, as an MVHR is most effective and beneficial in an airtight home. As a rule of thumb, a MVHR should be considered once the air tightness level of the home reaches 5m³/hr·m³@50Pa.

Mechanical ventilation with heat recovery can be divided into the two categories:

Centralised (or ducted)

Incorporates a main MVHR unit and manifold sited inside the home with a network of ducting to distribute the air to rooms. This type of system can be difficult to install in existing construction so is best suited to new builds and extensions. Given the volume of equipment involved, the system should be considered as part of the early stages of planning. Centralised systems are generally more effective than decentralised options.

Decentralised (through-wall unit)

Single point
Air is simultaneously supplied and extracted via a partitioned wall tube. Airflows cross over (but never mix) through the heat exchanger and heat is transferred continuously from one airflow to the other.

Two point (pared unit)
Two units work as one system, whereby one extracts air while the other supplies air—there is no classic heat exchanger like in the single point units or the centralised systems. As air flows through the units, heat is extracted and stored in a ceramic core—a block of ceramic with many air passages through it. Because the core will saturate with heat quite quickly, these units reverse direction every minute or so, allowing the heat that has been stored in the ceramic core to be transferred into the supply air stream.

3.2 Moisture management

Whilst there is minimal maintenance required of these systems, filters on the heat exchangers will need to be inspected and cleaned every 6 months and may also need to be replaced depending on the air quality of the area. Filtration should comprise a three-stage system including a prefilter, HEPA/F7 filter and a high capacity carbon cartridge on all outdoor air intakes. If the home is an area that may be at risk of bushfire smoke, homes can be future proofed to mitigate the health risks by putting in provisions for the addition of filters.

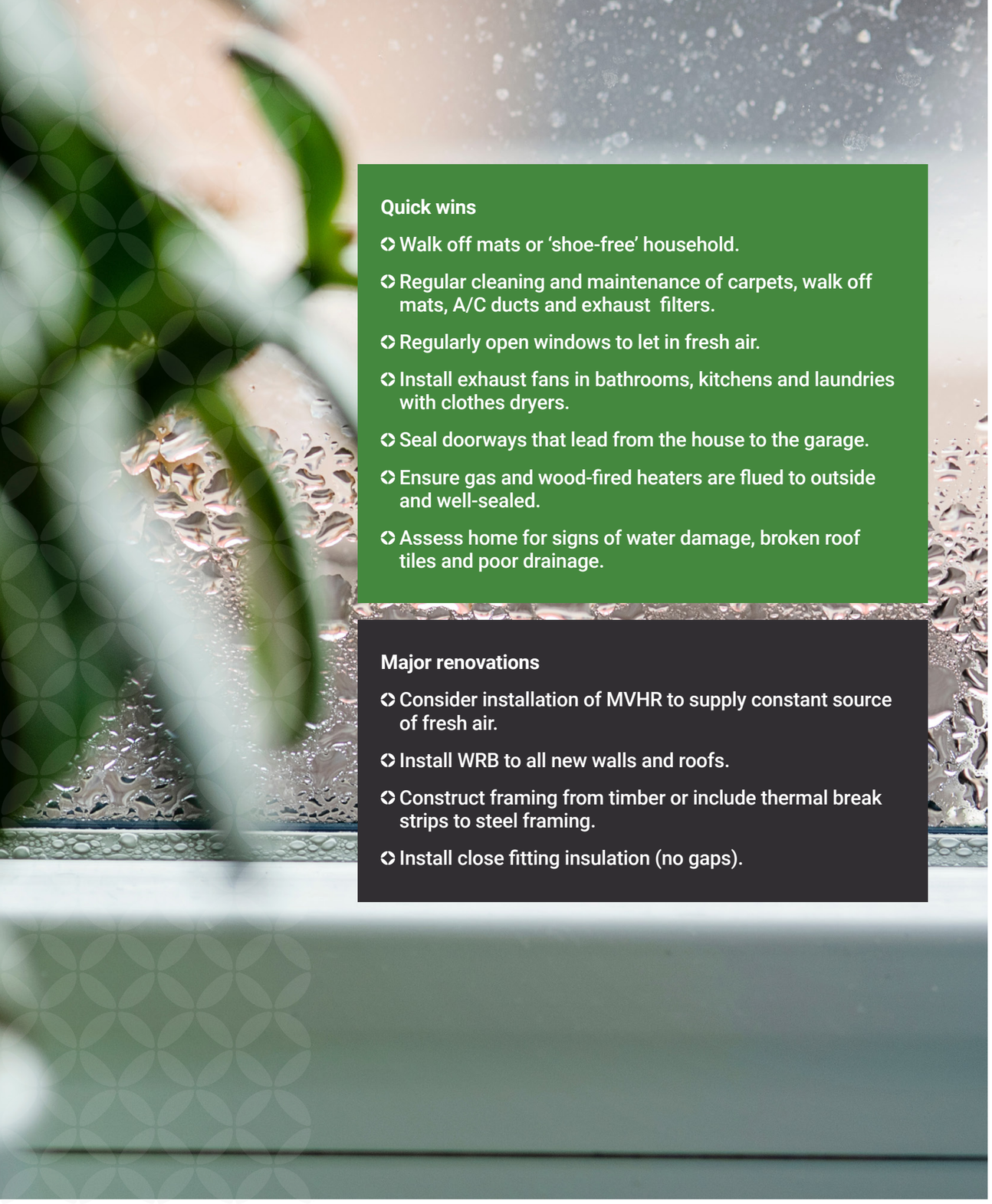
Condensation occurs when warm humid air meets a cooler surface and can occur on surfaces such as windows, or inside construction systems such as walls, ceilings, and floors. This is known as interstitial condensation and can lead to mould and mildew, causing building materials to rot and decay and be harmful to human health.

Condensation is a high risk in hot/humid climates during the summer/wet season and in cold climates during winter. Household activities such as showering, cooking and drying clothes contribute to water vapour inside the home. Older homes with poor sealing allow airflow and moist air to diffuse through the structure, whereas highly airtight homes will need additional ventilation to diffuse water vapour in the air and minimise risk.

Instances of thermal bridging, pathways for heat and cool to cross, can also lead to condensation risk within the structure. Thermal bridging commonly occurs where there are gaps in insulation or through steel framing, including window frames. Instances of thermal bridging can be reduced in the framing structure construction from timber or by providing thermal break strips to steel framing.

For any new construction it is recommended that a Weather Resistive Barrier (WRB) suitable for the climate region is installed in the external walls and roof, along with provision for a water drainage path. The vapour permeability of WRB are defined by AS/NZS 4200.1 and the table on the next page provides recommended Vapour Class per location and construction. In colder climate regions an additional internal wrap is also beneficial.

Existing homes should review flashings and drainage for walls and roof, as well as broken roof tiles and poor waterproofing to assess for leaks and points of water ingress and action rectification works. Signs of water leakage and condensation may not be obvious and may be observed as discolouration on plasterboard or new bubbles in old paintwork.



Quick wins

- Walk off mats or ‘shoe-free’ household.
- Regular cleaning and maintenance of carpets, walk off mats, A/C ducts and exhaust filters.
- Regularly open windows to let in fresh air.
- Install exhaust fans in bathrooms, kitchens and laundries with clothes dryers.
- Seal doorways that lead from the house to the garage.
- Ensure gas and wood-fired heaters are flued to outside and well-sealed.
- Assess home for signs of water damage, broken roof tiles and poor drainage.

Major renovations

- Consider installation of MVHR to supply constant source of fresh air.
- Install WRB to all new walls and roofs.
- Construct framing from timber or include thermal break strips to steel framing.
- Install close fitting insulation (no gaps).

FIGURE 23

Moisture management

Climate zone	External weather resistive barrier (WRB) *Wall*	*Roof*	Internal wall wrap
1	meets vapour class 1 or 2	Vapour barrier	Not required
2	meets vapour class 4		
3	Flexible vapour permeable WRB that meets vapour class 4 or rigid WRB that meets equivalent performance properties.	Vapour permeable	
4			
5			
6			Class 2 vapour barrier or variable vapour diffusion resistant wrap
7			
8			

Certification schemes assessing VOC content

GREEN TAG CERTIFIED

ENVIRONMENTALLY CERTIFIED — ECS LEVEL 2 CERTIFICATION

GECA

Certification schemes assessing sustainably sourced timber

FSC

PEFC

3.3 Light quality

Access to high quality daylight and artificial light is essential for occupant comfort and visual acuity for undertaking tasks around the home. Dark rooms may benefit from additional or larger windows or skylights to allow greater daylight access, however, be sure to balance access to daylight with thermal comfort and energy efficiency, which are impacted by large extents of glazed areas.

Artificial light is recommended to be provided through LED fixtures and have a minimum Colour Rendering Index (CRI) of 85. Selecting luminaries that include baffles or diffusers shield the direct light source and reduce unwanted glare.

LED lighting is affordable and energy efficient, with long service life, and should replace all old existing incandescent and halogen lighting.

3.4 Sustainable materials and toxicity

Materials, finishes, furnishings and other building products have a significant impact on occupant's health due to the off-gassing of Volatile Organic Compounds (VOCs), toxic substances which diminish the indoor air quality. Human health impacts include headaches, lethargy and can cause respiratory problems such as Asthma, a situation described as 'sick-building syndrome'.

VOCs are commonly found in paints and varnishes, adhesives, sealants, engineered timber such as floors and cabinets, benchtops, carpets and other textiles. Kitchen and bathroom renovations are key areas that attract VOCs, including formaldehyde in cabinetry and toxicity of waterproofing products and sealants. Over time VOCs will dissipate with regular ventilation, however VOCs can be reduced through considered product selection.

Low VOC paints are widely available, as well as options for timber cabinetry and benchtops with low formaldehyde content. Ask suppliers about the toxicity and environmental credentials of their products and refer to recommended VOC limits for various applications in Appendix B .

Also consider the wider environmental impact of selected products. Incorporating salvaged or second-hand materials and furnishings, restoring existing items, procuring locally made and materials with recycled content, reduce the carbon footprint of the renovation and facilitates a circular economy. Minimalist design can also reduce the overall materials and resources used.

Timber products are recommended to be sourced from sustainably managed forests, that maintain biodiversity, productivity and regeneration capacity, now and into the future. Many third-party environmental certification schemes exist to assist consumers in identifying healthier, sustainable products and, several examples are shown alongside. There are also online databases for some of these sustainability certified products, refer to the resources section 8.1.

4.0 Resilient homes

RESILIENT

18. CSIRO, "State of the Climate 2020"

Global climate change is affecting all facets of life and can lead to an increase in the frequency and intensity of natural disasters such as bushfire, flooding and extreme heat. These events can detrimentally affect our built environment, and in turn impact our health and wellbeing, and the reliability of infrastructure.

Australia's climate has warmed on average by 1.4 degrees Celsius since national records began in 1910, leading to increased dangerous fire weather days. Winter rainfall has been declining in the southern parts of Australia by up to 20 percent since the 1970s, however the intensity of extreme rainfall events has increased by around 10 per cent or more in recent decades, particularly in the northern parts of the country.[18]

A resilient home is one that has been built to be more robust than required by the minimum building standard and is thus able to better withstand natural disasters and future climate change conditions such as bushfires, flooding and extreme heat. The design of the home also considers its effect on the broader environment by reducing energy and water use and its impact on the community.

The following section outlines approaches in renovation activities to create a more resilient home for the future.

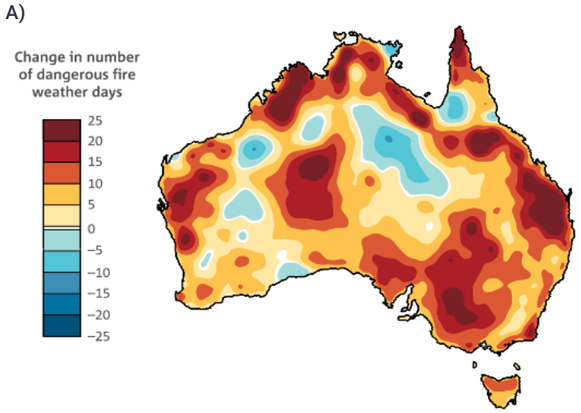
18. CSIRO, "State of the Climate 2020"

FIGURE 24

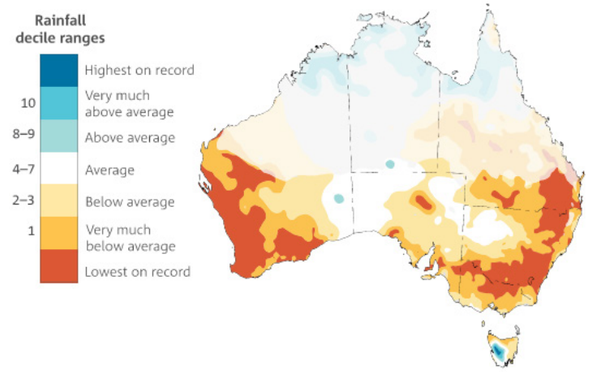
Climate observations – change in annual dangerous fire weather days since 1950 (A); Rainfall decline between April to October for the last 20 years (B) and; rainfall change for northern wet season for last 20 years (C)

SOURCE: CSIRO 'State of the Climate 2020'[18]

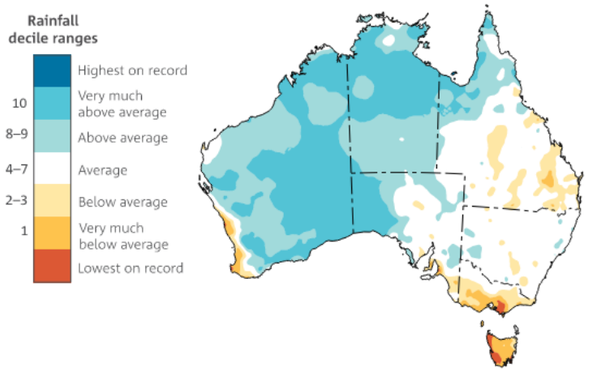
A)



B)



C)



4.1 Water use

Water is a precious resource and Australia is the driest inhabited continent on earth, yet per capita is amongst the highest consumers of water. Managing water in the home is relatively simple with considerable savings possible through replacing fixtures with efficient alternatives, taking shorter showers and limiting bath use.

When selecting new fixtures, water consumption can be compared using the Australian Government's Water Efficiency Labelling and Standards scheme (WELS). Fixtures and appliances sold in Australia are required to disclose rate of water consumption for the product and are given a star rating for easy comparison. This information is displayed on a label visually present on the product but can also be found online at waterrating.gov.au, where product ratings can be compared. Recommended minimum star ratings for fixtures and appliances are listed alongside as a guide.

Water use in the garden for irrigation can be considerable during Australia's hot summers. Installing a rainwater tank is a good strategy to reduce potable water use however, needs to be sized appropriately to take into consideration the homes catchment roof area and local climate with respect to rainfall. Several online calculators can be used to determine a suitable size, refer to resources section 8.1. Tanks are also best situated in higher locations if the property is on a slope, as gravity will reduce pumping power, and multiple tanks can be linked together, placed under a deck or even partially buried. Generally, approvals are not required for new tanks, however contact the local council for location specific requirements.

New construction may also provide the opportunity to further reduce potable water consumption by connecting a rainwater tank to the toilets for flushing and to the laundry for connection to the washing machine. Some areas may also provide connection to precinct recycled water, often termed 'purple pipe', which could also be reticulated to toilets and laundries, as well as to external garden taps for irrigation.

FIGURE 25

Example Water Rating label

SOURCE: Water Rating

Fixture type	Minimum WELS star rating
Taps - kitchen	4 Stars - max 7.5L/min
Taps – laundry and bathroom	5 Stars - max 6L/min
Toilets	4 Stars (dual flush) - max 3.5L/flush
Showers	4 Stars - max 7.5L/min
Appliance type	
Washing machine	4 Stars
Dishwasher	5 Stars

4.2 Sustainable garden

19. Australian Bureau of Statistics (ABS), "Household Water Consumption and Conservation Actions," 2011. [Online]. Available: https://www.abs.gov.au/ausstats/abs@.nsf/lookup/1345.4feature%20article1jan%202011

Around 40% of the average household's total water consumption is used for outside purposes, in particular for watering gardens and lawns.[19] Whilst a popular element to Australian homes, lawns require high amounts of water to maintain and decreasing grassed areas is a simple solution to reducing water consumption. Also, species like couch and buffalo require less water than other options.

Sustainable landscaping aims to work with the natural climate and cycles. Select species that are suitable for the location with low water needs. Native and indigenous plants typically require less water, will withstand periods of drought and provide a habitat for local birds and insects, increasing biodiversity. Contact the local council for advice, as many councils have a native plant nursery and native plant list, specific to the region.

Aim to retain as much existing vegetation as possible, particularly established trees that will take a long time to be replaced and may be home to local wildlife.

Utilising sub-surface drip irrigation reduces water consumption, in comparison to hand watering and sprinklers, by eliminating surface water evaporation and reducing the incidence of weeds. Water is applied directly to the root zone rather than to the soil surface where most weeds germinate.

Minimising hard surfaces to reduce stormwater runoff, replacing with garden beds and permeable surfaces will improve water retention. Using mulch will also assist in retaining soil moisture.

FIGURE 26

Australian Native Garden

SOURCE: Houzz

4.3 Heat resilience

Urban areas that include large extents of hard surfaces, absorb, store and radiate heat, leading to the urban heat island effect. The impact of urban heat island effect on a home's peak electricity demand ranges from 0.45% to 4.5% and can increase cooling demand by up to 100%.[20] Extreme heat and climate change further exacerbate this effect.

Reduce hardscaping areas in favour of vegetation and garden beds and prioritise shading these areas with structures such as pergolas or with overhanging trees.

Select lighter colours for paving and roofing that will absorb and radiate less heat. A home's roof will likely cover a large portion of the site, having a significant impact on reducing urban heat island effect. Roofing products can be identified with a Solar Reflective Index (SRI), which is a measure of the solar radiation that is reflected back by a rooftop surface and the emissivity of the surface. For homes with a shallow roof pitch less than 15 degrees, a three-year SRI of 64 at minimum is recommended. Homes with taller roof pitch, greater than 15 degrees, should aim for a three-year SRI of at least 34.

20. Santamouris M, Haddad S, Fiorito F, Osmond P, Ding L, Prasad D, Zhai X, Wang R, "Urban Heat Island and Overheating Characteristics in Sydney, Australia. An Analysis of Multiyear Measurements," 2017

4.4 Resilience essentials

In Australia, the average life of a brick home is 88 years and a timber home is 58 years.[21] Protecting the home against a changing climate will ensure that it remains resilient and comfortable for years to come. Extreme heat, bushfire and flooding are top priorities for a resilient home and regular property maintenance is an important first step in prevention.

Contact the local council to find out the most likely risks the home is exposed to, both now and any projected future risks, relevant to the specific location and elevation of the property. You can ask to see Council maps that show flood, bushfire risk and coastal erosion for example. Many State Government departments also have good information about projected climate change risks to regions (not generally site specific) and this can help you to understand any long term preparations you might need to consider.

Maintenance

In order to keep installed systems and assets operating optimally, they need to be maintained. This can include appliances, standalone structures and installed systems. Having adequate access to these items should be included as part of the design process. The following table includes a maintenance schedule that is recommended to follow to maintain performance of installed systems.

21. M. Snow and D. Prasad, "Climate Change Adaptation for Building Designers: An Introduction," 2011

Home systems	Inspection frequency	Inspect	Maintenance frequency
Hot Water Systems	Every 6 months	Dirt in the rainwater tank, leakage, etc	Annual (if needed)
Ventilation Systems	Every 3 months	Noise from MHRV systems. Check both filters F7 and G4 as per the manual provided	3, 6 or 12 months, depending on inspection
Solar Panels	Every 3 months	Check for any dirt being accumulated on the panels.	3,6 or 12 months, depending on inspection
Rainwater Tank	Every 6 months	Dirt in the rainwater tank, leakage, etc	Annual (if needed)

Storm

Ensure that tiles, corrugated sheets or other coverings on your roof are secure and can withstand high winds. Regular checks are important, especially after a storm event. Take care when looking around your property after an extreme event as damage may have occurred. If you see any significant damage it is a good idea to call your insurance company to discuss your situation.

As well as checking your roof, after a storm it's a good idea to look at drains, drainpipes, fences, large trees, and anything else that you think may have been impacted by the storm. Keeping your gutters and drains clear of debris, and trimming dead wood and damaged branches regularly can help to keep you and your property safe during storms.

Extreme heat

Mitigating effects of extreme heat and increasing temperatures generally, can be achieved through addition of shading strategies and improvements to the homes thermal performance as discussed in section 2.1.1. Ensuring outdoor services such as heating, ventilation and cooling systems, and hot-water heaters are positioned in areas of shade, reduces the risk of failure due to exposure to extreme heat and increases system efficiency.

22. Western Australian Planning Commission, "Guidelines for Planning in Bushfire Prone Areas," 2017.

18. CSIRO, "State of the Climate 2020"

Bushfire

Dangerous fire weather days have significantly increased in Australia in recent decades, particularly in the south and east during spring and summer. Dry lightning that occurs without significant rainfall is the primary source of natural ignition for bushfires.[18] Bushfire attack mechanisms on the home include flame contact, ember attack, radiant heat, wind, and smoke.

Properties are classified by a Bushfire Attack Level (BAL) as a means of measuring the risk of a house being impacted by a bushfire event. A BAL rating provides a basis for establishing the requirements for construction under the Australian Standard AS 3959-2009, for Construction of Buildings in Bushfire Prone Areas. These requirements pertain to the installation of rated windows and doors, fire shutters and screens, roof sarking, combustible materials and subfloor enclosure. Refer to the below summary of classifications. Where the home is greater than 100m from any classified vegetation the BAL rating will more than likely be BAL–LOW and will not require any special construction requirements. Contact the local council, rural fire service or a bushfire consultant to determine the BAL rating for the property.

Ember attack is the most common cause of building damage or destruction from bushfires, travelling well in advance of the fire front and entering the home through gaps to ignite the building's interior. Embers can also ignite debris on roofs, in gutters and windowsills or under raised floors, including decks. Regular maintenance of rubbish and debris is essential to protect the home. Where possible, create a clear protection zone around the perimeter of the house for 20 meters, with reduced vegetation and no overhanging trees.

Seal up gaps and cracks externally, ensuring no more than a 2mm gap. Repair any broken roof tiles and enclose open eaves or roof gables and raised floors including decks. Fitting metal fly wire mesh or solid screens to windows, doors, ventilators, and skylights can also protect these openings against ember attack.

For new construction works, simplify the roofline and house outline to reduce the opportunity for debris and embers to build up, for example in roof valleys. Metal roof sheeting offers greater protection than tiled roofs as it is firmly secured and sealed at junctions. However, new tiled roofs should include an appropriate fire rated sarking insulation immediately below roof tiles. Also select non-combustible building materials and fire retardant products (for e.g. paint) where possible.

Sprinkler systems to wet down the house and garden to reduce the effect of radiant heat, sparks and embers, alongside an independent firefighting water supply, such as a tank or dam, is a financial investment that should be considered with respect to the BAL rating for the location and bushfire action plan.

FIGURE 27

BAL ratings in context

SOURCE: WA Planning Commission 'Guidelines for Planning in Bushfire Prone Areas' [22]

22. Western Australian Planning Commission, "Guidelines for Planning in Bushfire Prone Areas," 2017.
15. Rewiring Australia, "Castles & Cars: Savings in the Suburbs through Electrifying Everything," 2021

Flooding

Flash flooding has increased in recent decades as a result of storms and cyclone activity and homes at risk should consider mitigation strategies, such as flood barriers; pervious pavement around the home; water sensitive urban design (WSUD) techniques; increasing stormwater pipe sizing to accommodate more intense downfalls; installing tiled flooring to ground floor areas; and elevating new structures above flood risk level.

Regular cleaning of gutters and drains to clear debris can help to reduce the likelihood of your drains being overwhelmed during heavy rain.

Electric vehicles

Electric vehicles (EVs) are predicted to be the same price as their petrol counterparts in 2026 and 30% cheaper by 2030. Charging an EV from grid electricity is about half the cost of fuelling a petrol car, and even less so when charging the EV from rooftop solar and home battery.[15] Driven by the increasing cost of fuel and restrictions to the sale of petrol vehicles, the transition to EVs is inevitable.

Most EVs can be charged from a standard power point or come with a charger as part of the sale of the car. Consult with an electrician to ensure the existing infrastructure can handle the additional electrical load as older homes may not have adequate electrical supply. This is especially the case if installing a fast charger or multiple chargers (for multiple vehicles). Where possible it is best to upgrade the wiring and have a dedicated supply to the charger, which also needs to be close by to the vehicle.

If the renovations already include upgrades to the electrical supply to the home or construction of a new garage (or changes to an existing one), consider putting in provisions for future EV charging, allowing for additional load capacity and dedicated wiring.

Quick wins

- Install new fixtures and appliances with high WELS ratings.
- Reduce lawn area in favour of native plantings with low water requirement.
- Minimise external hard surfaces.
- Seal up gaps, repair broken roof tiles and fit metal mesh to openings.

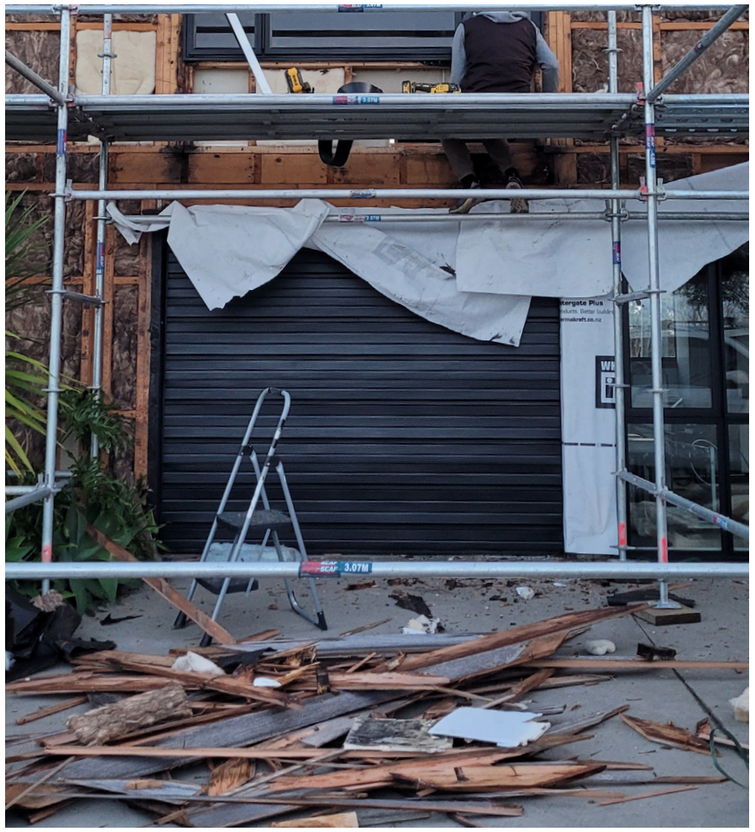
Major renovations

- Install rainwater tank and consider reticulation to toilets and laundry.
- Install sub-surface drip irrigation.
- Position services (i.e. A/C, DHW) in shade.
- Simplify roofline and install light coloured metal roof sheeting.
- Select non-combustible and salvaged building materials.
- Consider installing sprinkler system with fire water tanks.
- Renovate existing home, rather than demolishing and building new.

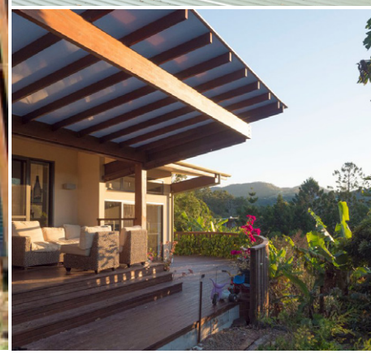
4.5 Renovation waste

Construction and demolition activities produce about 44% of Australia's total waste, however around 77% of this is recovered or recycled.[2] Renovating an existing house rather than demolishing for a new build will reduce waste and embodied energy. Consider the design of new construction – smaller homes will produce less waste during construction and at end of life, whilst also using less operational energy. Second-hand building materials and elements could also be used, such as bricks, metal sheeting, windows and doors, timber and plasterboard. Create a waste management plan for the project and discuss this with all parties, particularly subcontractors, to ensure that it is implemented to achieve the targeted waste reduction.

2. Department of Agriculture, Water and the Environment, "National Waste Report," 2020



5.0
Case studies



CASE STUDY

5.1 Yagoi 100

Located within the international award-winning Ecovillage at Currumbin in tropical South-East Queensland, ‘Yagoi 100’ is a house designed to incorporate the best of the currently available environmentally sustainable design principles and products.

Since the original house was built in 2009, the owners have continued to improve the sustainability and resilience of the home by increasing the Solar PV array to 11kW and removing the gas appliances, enabling the home to achieve net zero emissions.

A 13kW battery system also allows the house to operate on local renewable energy throughout the night or when there is a regional power blackout, or charge an electric vehicle. The home is connected to a virtual power plant, enabling the local electricity retailer to draw energy from the battery storage to support the grid network during instability.

To protect the home from the hot summer sun, a second-hand insulated shutter blind was added to a west facing window. Similarly, a shade sail is erected over the eastern study window in October and left in place until autumn, in which it is packed up allowing heat gain from the sun to warm the home in the cooler months. Cellular blinds have also been added to the windows.

Passive design was considered in the extension to the home in 2022, orientating all new rooms to face north with generous eave overhangs. Sustainable materials were prioritised in the construction, including low VOC paints and benchtops, Low-E double-glazed uPVC framed windows and recycled balustrade timber.

The extension also considered adaptability, designing wet areas for accessibility with non-slip floors and adjustable height shower heads and extra wide doorways to cater for wheelchair access. These provisions will allow the occupants to remain in the home as circumstances change over time.

CASE STUDY

5.2 1950s house renovation and extension

Mylor is located in the Adelaide Hills in South Australia, in a climate that receives both long hot summers and cold, wet winters.

The original 1950's house was situated on a parcel of land with a northerly aspect and great views, and whilst the double brick construction provided a solid base, the house was small, dark and outdated. Rather than demolish the home, the owners decided to reuse the main living and bedroom areas but optimise the internal layout to expand the northern aspect, making the most of the winter sun for passive heating in the cold months, whilst minimising the western aspect to protect the property from the harsh afternoon sun.

The windows were replaced with double glazing throughout, and high levels of insulation were included in the walls and ceiling space to improve thermal performance. The house is situated on the top of a ridge, so the windows also included a high percentage of openable elements to encourage cross flow ventilation and enable night purging in the summer. Ceiling fans were added to reduce the reliance on air conditioning.

A wood burning stove provides winter heating, with all wood being gathered from trees on the property, which also helps to manage the fire load on the property, which is an important consideration in the Adelaide Hills. To build the home's resiliency against bushfire, a clear protection zone was established around the home , consisting of grassed areas only and minimal vegetation and trees. 100,000 litres of firefighting rainwater tanks were also included alongside sprinkler systems to allow the home to be defendable in the event of a bushfire.

Natural materials were used throughout, including wool carpets, local stone and timber elements, to connect the home to the external landscape and outdoor living areas.

A large solar array has been installed on the roof and provision made for a future EV car in the carport.

CASE STUDY

5.3 Little Loft House – light house architecture & science

The Little Loft House is a rejection of the 'disposable' mindset by breathing new life into a home that many would consider ripe for a 'knock-down/rebuild'. What was an old, cold and unappealing dysfunctional house located in Suburban Canberra, is now a joyous, comfortable, energy and space efficient, multi-functional home that can adapt to the changing needs of the family.

Working mainly within the original footprint, the existing external walls, roof and slab were all largely retained, as were some internal walls. However ,the floor plan was rejigged and extended by 13m^2 to create a new family home of just 136m^2, with more functional space and better connection to the outdoors.

While the old house was only NatHERS 3.8 stars, removing wall linings to install high levels of insulation in walls and ceiling, retrofitting windows for high performance uPVC framed low-e double-glazing, alongside optimising window to floor ratios and improving northern solar access, improved the NatHERS rating to 7.7 Stars. The tool was used in this project to inform design changes for increased comfort and energy efficiency.

The new home also achieved an incredible air leakage rate of 2.5 ACH@50Pa (roughly equivalent to 2.5m^3/hr·m^3@50P[22]). This level of airtightness was achieved using standard residential construction materials and methodologies, including removing and sealing all ceiling penetrations (vents, ducts downlights), and without the use of internal air barrier membranes and services cavities, which keeps construction costs much lower and provides excellent thermal bang-for-buck.

This is now an all-electric home with the heating, hot water and cooking converted from gas to electric. The gas meter was decommissioned.

Actual total energy consumption has dropped by 69% and comfort levels have been massively improved. The savings and comfort improvements are very real. This gorgeous little house is 47% smaller than the average new Canberra home and uses 80% less energy!

23. AIRAH, "Air Tightness Metrics to Improve Australian Building Envelope Integrity," 2017

6.0 Key stakeholders

6.1 Executing a sustainable renovation

Collaboration between stakeholders is essential to achieve successful outcomes for a sustainable renovation. All parties should be proactive in identifying opportunities and revaluating business-as-usual strategies against the project's sustainability aspirations.

Local council

- Can advise on local environmental hazards, such as flooding and bushfires.
- Provide information on local building restrictions or requirements applicable to renovations, such as when approvals are needed, bushfire preparedness and design criteria.

Home owner

- Select building professionals that understand and align with the project's sustainability goals.
- Be open to compromise - the sustainable choice may not be the preferred option for a number of reasons. Weigh up the benefits and find the right balance.
- Operate the home efficiently - utilise adjustable shading as intended, open and close windows in response to the climate and turn off appliances that are not in use. Sustainable design, materials and technologies are only one facet of a sustainable home.

Builder

- Execute homeowner's/client's goals for achieving an energy efficient & sustainable home.
- Ensure quality construction with careful attention to building sealing at all junctions and installation of insulation (no gaps) for airtightness and thermal performance.
- Manage and recycle C&D waste, avoid overordering materials and use materials efficiently, reducing unnecessary offcuts.
- Use sustainable, low-VOC building materials.

Architect /designer

- Incorporate passive design strategies into all home designs.
- Consider what can be reused from the existing house.
- Encourage clients to consider minimalist designs and sustainable alternatives to materials.
- Engage with a NatHERS Assessor for early concept design feedback on energy efficiency and passive design.

7.0 Considering costs + benefits

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7.1 Government incentives

Several financial incentive schemes and grant programs exist to support sustainable homes, particularly focusing on energy and water efficiency. Opportunities vary for each location, as offered by state and territory governments and local councils. Often retailers will be aware of incentives that relate to their products and offer customers a financial benefit.

Current available opportunities (as at May 2023) can be found on the rebates search on the Department of Climate Change, Energy, the Environment and Water website here.

7.2 Financing

Financial institutions may also offer low or no-interest loan schemes for sustainable building and energy efficiency upgrades. By working with the finance sector, the GBCA has advanced two green home loan products that may be suitable for major renovations. These products are available as at May 2023:

Commonwealth Bank

Green Home Loan which offers reduced interest rates for homes that are fully electric with 7 stars Anther's rating as well as minimum solar system (based on size of home). Conditions apply.

Bank Australia

Green Plus Home Loan which offers a discount interest rate for homes that have 7.5 stars NatHERS rating as well as a solar system of 3 kW or higher.

NAB

An energy efficiency incentive which offers an interest rate discount on a home loan for homes that have a NatHERS 7-star rating or a GBCA Green Star rating.

Westpac

Westpac announced plans to launch a new Green Home Loan offer with a discounted interest rate for eligible customers.

7.3 Insurances

Undertaking renovations to the home, particularly when increasing the size or adding technology, will likely increase the overall value of the home. It also means there could be changes that need to be made to home insurance. Check your coverage still meets your needs and your sum insured for the property is updated. In addition, in locations where climate change impacts are increasing the likelihood and occurrence of extreme weather events, it is important to re-evaluate home building insurance (and the associated sum insured for the property). Always check with your insurer about what is covered and any exclusions or exclusion periods so that you understand your policy and it meets your situation. It is always best to reach out to your insurer if you are unsure about the best options for your situation.

7.4 Cost vs benefit

15. Rewiring Australia, "Castles & Cars: Savings in the Suburbs through Electrifying Everything," 2021
24. University of Melbourne, "Energy efficient homes attract premium sale and rental prices, study finds," 2018

Financial investment associated with sustainable renovations should consider multiple factors when weighing up opportunities, including the upfront capital cost, the home's potential increase in value, ongoing operational costs, practical amenity, as well as health and wellbeing of the persons living in the house.

Undertaking improvements to any home has the potential to increase the property's value. A study undertaken by The University of Melbourne analysed tens of thousands of property transactions between 2011-2016 in the Australian Capital Territory, where energy efficiency mandatory disclosure has been in place since the late 1990s. The research determined that buyers and renters value energy efficiency, increasing sale prices by up to 9.4 per cent.[24] Impacts of climate change and increasing energy prices has the potential to continue to drive demand for energy efficient homes.

Whilst the upfront cost of any investment is likely to be front of mind, it is important to consider this alongside ongoing operational costs and subsequent payback periods. For example, opting to increase the homes thermal performance with insulation upgrades or improved windows may have a significant capital expense upfront, however the home will remain comfortable for a greater portion of the year, reducing the need to switch on heaters and air conditioners, which in turn will reduce energy consumption and energy bills. Fortunately, there are many simple inexpensive strategies that that can be implemented in the first instance, such as building sealing activities, that can positively impact electricity consumption, making the home more affordable to operate.

The average Australian household is estimated to currently use just over 100kWh of energy per day, including energy required to power personal vehicles. If all users switched to all-electric solutions, this figure is estimated to reduce to 37kWh, which can be almost completely met by a 10-12kW capacity solar installation and compatible battery storage solution. By 2030 it is projected that households could save $5000 per year by switching to all-electric solutions.[15]

Whilst some strategies may only be possible or practical to be implemented at the time of construction, such as designing layout for passive design, other initiatives such as solar PV and battery storage, could be implemented over time. Considering a forward plan of sustainability aspirations to future proof the home could be a good way to prioritise immediate activities and allocate available budget. Technologies such as home battery storage are estimated to decrease in cost rapidly over the coming years, even faster than Solar PV over the last decade.[15] As such it is worth considering whether planning for future investment is more suitable, such as by installing 'battery ready' solar PV systems instead.

To assist in decision making, strategies and initiatives for sustainable renovations discussed in this guide have been summarised into three tiers against broad benefits, identifying simple solutions for improving the home, through to considerations for new construction and outstanding practice. Generally, tier 1 strategies are affordable solutions versus benefit, whereas tier 3 options require greater financial investment and should be considered against specific project benefits.

FIGURE 28

Household savings from electrification

SOURCE: Rewiring Australia[15]

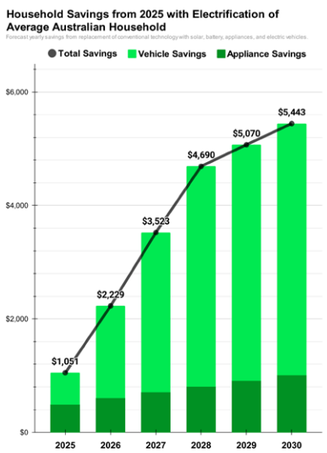


TABLE 1

Summary of sustainable renovation initiatives by affordability and benefit

	TIER 1	TIER 2	TIER 3
	$ - Quick wins and affordable minor renovations	$$ - Considerations for major renovations and best practice new construction	$$$ - Outstanding practice that requires significant financial investment
Benefit: Improve comfort and reduce reliance on mechanical heating and cooling (saving costs operational energy)			
	• Retrofit ceiling insulation, R4.0 or higher. • Install close fitting insulation (no gaps). • Install external shading, such as roller blinds, to problematic windows that emit summer sun, particularly on the east and west. • Install ceiling fans with multi-directional airflow. • Install Low-E film, tinting or secondary glazing to windows. • Undertake draught sealing, including weather strips to doors and windows, dampers to vents and sealing gaps and cracks.	• Consider the geometry and layout, ensuring main living areas and windows face north where practical. • Minimise glazing to all orientations except north. • Install insulation to walls, roof and suspended floors in all new construction and wherever there is access in existing fabric. • Include shading or eaves into the design of new construction to restrict summer sun. • Consider inclusion of thermal mass elements such as Concrete Slab on Ground or feature masonry internal walls. • Construct framing from timber or include thermal break strips to steel framing. • Include vapour permeable membranes within wall and roof constructions with effectively taped joins and junctions, to create an air-tight barrier.	• Install high-performance double-glazed windows. • Consider higher performing framing systems.

TIER 1

$ - Quick wins and affordable minor renovations

TIER 2

$$ - Considerations for major renovations and best practice new construction

TIER 3

$$$ - Outstanding practice that requires significant financial investment

Benefit: Improve energy and water efficiency, saving cost of operational energy

- Turn down the thermostat on your hot water service (if possible) to around 50°C.
- Switch to water efficient showerheads and taps and take shorter showers.
- Use smart plugs to track consumption of major appliances.
- Replace old inefficient appliances.
- Replace lighting with efficient LED luminaires.
- Install new fixtures and appliances with high WELS ratings.
- Reduce lawn area in favour of native plantings with low water requirement.
- Replace hot water service for efficient Electric Heat Pump or Solar Electric Boosted System (avoid gas or gas boosted system).
- Select efficient ALL-electric appliances and air conditioning (refer star rating guide), including induction cooktop, avoid gas ovens and stoves.
- Remove and/or replace gas heating appliances with electric alternative.
- Consider installing Solar PV and battery storage.
- Install rainwater tank and consider reticulation to toilets and laundry.
- Install sub-surface drip irrigation.
- Upgrade to a smart meter or home automation system that tracks energy use and allows solar PV and peak load management.

Benefit: Reduce carbon emissions

- Switch to GreenPower as part of your energy contract.
- Use second-hand or salvaged building materials.
- Transition the home to being ALL-electric, replacing gas appliances with electric alternatives.
- Renovate existing home, rather than demolishing and building new.

Benefit: Improve health and wellbeing of occupants

- Walk off mats or ‘shoe-free’ household.
- Install exhaust fans in bathrooms, kitchens and laundries with clothes dryers.
- Seal doorways that lead from the house to the garage.
- Ensure gas and wood-fired heaters are flued to outside and well-sealed – consider avoiding altogether.
- Assess home for signs of water damage, broken roof tiles and poor drainage.
- Install WRB to all new walls and roofs.
- Select Low VOC building products, including paints, carpets, joinery (engineered timber), sealants and adhesives.
- Consider installation of MVHR to supply constant source of fresh air.
- Replacing your gas cooktop with an induction cooktop also has health benefits (12% of childhood asthma is attributed to gas stoves).

TIER 1

$ - Quick wins and affordable minor renovations

TIER 2

$$ - Considerations for major renovations and best practice new construction

TIER 3

$$$ - Outstanding practice that requires significant financial investment

Benefit: May help to create a more resilient home, against a changing climate and extreme weather events (i.e., bushfire, extreme heat, flooding and storms)

Bushfire

- Seal up gaps, repair broken roof tiles and consider fitting metal mesh to openings in bushfire prone areas.
- Avoid planting trees, or large groups of shrubs close to buildings in bush fire prone areas.
- Install insulating blinds or curtains. Blinds and curtains can help to keep hot air out of your home.
- Use non-combustible gutters and gutter guard in bushfire prone areas.
- Consider using fire resistant insulation in your home.
- Use fire retardant products (for e.g. paint).

Extreme Heat

- Consider installing light coloured permeable paving. Light paving can help to reduce heat.
- Install insulating blinds or curtains. Blinds and curtains can help to keep hot air out of your home.
- Consider the use of grass, plantings and water features on your property to keep temperatures down during hotter months.

Flood & Storms

- Minimise external hard surfaces in flood prone areas. More porous surfaces allow water to naturally drain away into the ground. Large areas of hard surfaces outside can increase the speed at which stormwater travels and reduce the ability of water to be absorbed naturally into the ground.
- Consider installing light coloured permeable paving. Permeable paving helps allow water to drain away.
- Raise appliances like your washing machine and fridge off the floor in flood prone areas if at ground level. Or consider storing valuable or essential household items at higher levels to minimise exposure to rising water levels.

Bushfire

- Select non-combustible building materials for home construction, renovation and repairs.
- Consider using non-combustible materials to build decks, carports, fences and pergolas.
- Locate electricity and other services underground. This can help to protect them from fire damage.

Extreme Heat

- Position services (for e.g. air conditioning, Domestic Hot Water) in shade to avoid overheating.

Flood & Storms

- On ground level of home consider installing tiles or concrete flooring in flood prone areas. This can help to reduce damage, clean up time and costs after a flood.
- In flood prone areas consider using removable cabinetry on ground floors. This allows you to move cabinetry to higher ground if a flood is predicted.
- If appropriate, raise services (e.g. electricity and gas) above floor level to avoid contact with floodwater.
- Where appropriate, seek advice on a localised drainage system tailored to your site that takes into account projected increases in rainfall intensity and flooding.
- Consider increasing the capacity of your roof drainage system.
- Seek advice if your roof is old or damaged and consider replacing it with stronger materials and an upgraded tie down system.
- If you live on the coast, consider whether or not retaining walls or other coastal erosion measures would provide your property with additional protection during storms.

Bushfire

- Consider installing an internal sprinkler system with fire water tanks.
- Consider installing an external spray system on your roof in bushfire prone areas.
- Consider installing fire resistant shutters on all windows of the home in bush fire prone areas.
- Consider installing ember proof metal screens in bushfire prone areas.
- Simplify roofline and install light coloured metal roof sheeting. This may help to reduce fire risk.
- Consider having large rainwater tanks / storage installed underground or built using non-combustible materials.

Flood & Storms

- If appropriate, raise floor level of home to reduce risk of floodwaters entering the property. You need to understand the height of past floods and take into account possible increases in future floods.
- Consider installing cyclone shutters on your windows and doors.
- Consider using cyclone rated roof fixings to increase the strength of your roof during periods of strong winds.
- Check if your shed is anchored to the ground, if not, consider purchasing a cyclone kit to reinforce its strength.
- Consider installing a garage door that is rated for high wind conditions.

8.0 Codes and tools for planning and construction

8.1 The National Construction Code

The National Construction Code (NCC) is Australia's primary set of technical design and construction provisions for buildings. As a performance-based code, it sets the minimum required level for the safety, health, amenity, accessibility, and sustainability of certain buildings. The Australian Building Codes Board (ABCB), on behalf of the Australian Government and each State and Territory government, produces and maintains the NCC.

Generally, the NCC is applied to new buildings, however can also be applicable to major renovations. If the proposed building works require building consent approval by authorities, they will be subject to the regulations and provisions in the NCC.

The NCC groups buildings and structures by the purpose for which they are designed, constructed or adapted to be used, assigning each type of building or structure with a classification. Residential housing is classified as 'Class 1' group of buildings and provisions for this group are outlined in the NCC Volume 2. Apartment buildings are classified as 'Class 2' group of buildings and provisions for this group are outlined in the NCC Volume 1, alongside other buildings of a commercial nature considered in Classes 3-9 groups.

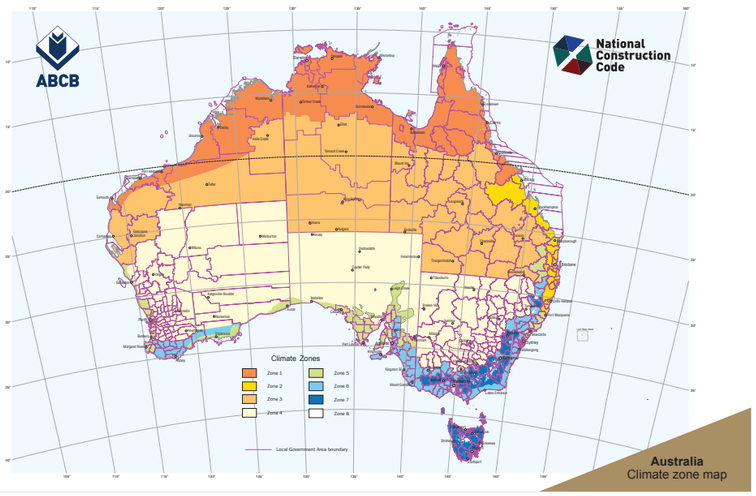
Australia has a varied climate, leading to different locations around the country having different heating and cooling requirements. To account for these differences the Energy Efficiency Provisions vary from location to location. For simplicity, the NCC groups locations with approximately similar climates to create eight climate zones.

The following provides a brief description of each NCC climate zone, which are also illustrated in the climate zone map alongside.

FIGURE 29

Climate Zone Map Australia

SOURCE: Australian Building Codes Board (ABCB)



8.2 The Nationwide House Energy Rating Scheme

9. Sustainability Victoria, "Energy Efficiency Upgrade Potential of Existing Victorian Houses," 2015.

The Nationwide House Energy Rating Scheme (NatHERS) uses computer modelling simulation to measure a home's energy efficiency to generate a star rating. It was first introduced in 1993 and provides a rating out of 10 stars – the higher the star rating, the less energy needed to heat and cool the home to keep it comfortable. The assessment and calculation consider the whole house and construction elements, however exclude appliances and renewable energy at the time this guide was written. The scheme and software assessment is also applicable to individual apartments.

NatHERS is administered by the Department of Climate Change, Energy, the Environment and Water on behalf of the states and territories. Computer simulation software used under the scheme are developed based on the CSIRO Chenath calculation engine, and include FirstRate5, AccuRate Sustainability, BERS Pro and HERO.

FIGURE 29

Example NatHERS Certificate

SOURCE: Nationwide Housing Energy Rating Scheme

The NCC outlines minimum star ratings required to be achieved for new homes using the NatHERS scheme as a building compliance pathway. Accredited assessors undertake the assessment and issue a formal certificate to verify the homes performance, which includes a summary of the construction elements and insulation levels, as well as the estimated annual heating and cooling requirements.

Typically, NatHERS is not used to assess renovations as there is complexity in determining existing building fabric (i.e., insulation levels concealed within walls), and the impact of older construction elements that were not subject to current NCC energy efficiency provisions result in lower star ratings. A review of 60 existing households in Victoria determined the average star rating for a home built prior to 1990 is 1.57 Stars, whereas post 1990 the average star rating is 3.14 Stars, an increase supported by the introduction of the NatHERS scheme, however still short of the 7 stars currently required for new homes.[9]

The scheme provides an opportunity to benchmark an existing home with an 'In-Home' assessment by engaging with a certified NatHERS Assessor. Once the existing star rating is established, it will also be possible for the assessor to test the impact of possible renovations and improvements to assist with decision making. Practical upgrades have the potential to improve the performance of a home's envelope to achieve at least 5 stars.[9]

8.3 BASIX (NSW)

The Building Sustainability Index (BASIX) is a state-based planning tool applicable to residential dwelling types in New South Wales. BASIX forms part of the development application process and assesses requirements for water and energy usage, and thermal comfort performance.

The tool is applicable to alterations and additions to dwellings that cost $50,000 or more and incorporates the NatHERS star rating assessments. In addition to predicated heating and cooling energy demand determined by the NatHERS star rating, the BASIX tool includes requirements for hot water systems, fixtures, lighting, pools, spas, and alternative energy sources.

Since 2004 when the scheme first commenced, more than 500,000 BASIX-compliant homes are estimated to have saved 12.3 million tonnes of greenhouse gas emissions, and 340 billion litres of drinking water.

8.4 BESS (VIC)

The Built Environment Sustainability Scorecard (BESS) is a dedicated tool in Victoria for assessing sustainable design at the planning permit stage, which commenced in 2015. The tool is owned by the Municipal Association of Victoria (MAV) and operated by The Council Alliance for a Sustainable Built Environment (CASBE) on behalf of subscribing member councils.

In these subscriber councils, planning permit applicants can prepare a BESS report for a development located within that municipality, assessing a range of factors that affect the natural environment as well as the well-being of building occupants. BESS includes water, energy, stormwater quality, indoor environment quality, transport, waste, urban ecology, building management to support these and innovation.

BESS forms part of the Victorian Sustainable Design Assessment in the Planning Process (SDAPP) framework, which was developed by Victorian councils to provide a streamlined and consistent methodology for requesting, receiving and assessing built environment sustainability outcomes through the planning process.

The tool can also be used by any member of the community to assess the design of their home and find ways to make it more sustainable.

8.5 Residential efficiency scorecard

The residential efficiency scorecard assesses a home's energy and comfort performance. Undertaken by an accredited professional, as well as providing an energy rating, it also identifies opportunities for improvement.

8.6 Green Star Homes

Green Star Homes is a leading rating tool for new homes, released by the Green Building Council of Australia (GBCA) in August 2021, following years of success with Green Star ratings for commercial buildings.

The Green Star Homes standard seeks to create highly efficient, fossil fuel free homes, powered by renewables that are healthy and resilient for all Australians. The third-party certification provides volume home builders with assurance from Australia's leading authority on sustainable buildings with the Green Star Homes Trademark, which can be used to communicate a standard home or product line's sustainable achievements to customers.

Green Star Homes has three categories focussing on core outcomes that define what a healthy, resilient and positive home is. Each category contains a number of credits with requirements that must be met to meet the Green Star Homes Standard. This guide will align with the Green Star Homes Standard to provide practical opportunities for home renovations.

The development of Green Star Homes had three distinct stages: scoping phase, consultation phase and the development phase.

The scoping phase began with the development of the *Future Homes Discussion Paper*, released in 2018. This discussion paper was developed with the assistance of a dedicated residential housing working group and outlined the key challenges and opportunities for improving the standard of residential housing in Australia.

The consultation phase was an iterative process with a high level of engagement with industry to identify existing programs and schemes, challenges and opportunities faced by volume home builders, opportunities for financial incentives and formed the technical foundations for developing a Standard. This feedback informed the development of the *Future Homes Strategy*, released in May 2020, alongside the Draft Green Star Homes Standard for public consultation.

In addition to the draft credits, this consultation phase also sought comments on project eligibility, the net zero energy definition and the certification process, in which over 50 written submissions were received and considered.

To test the standard as it was being developed, and to ensure it was fit for purpose, with industry buy-in, an Early Access Program was introduced to work with volume home builders and residential developers (private and government land agencies) to test and pilot the Draft Standard. The goal was to have a cohort of projects that could serve as a test case for the multiple approaches proposed in the Standard. The GBCA worked with the Homes Advisory Panel and the Homes Early Access projects to finalise the credits and receive endorsement and approval through the GBCA governance process.

9.0 Additional resources

9.1 Resources

Further information on concepts discussed in this guide can be found at the following links:

Your Home – Australia's Guide to Environmentally Sustainable Homes

Energy Rating

Water Rating

Renew E-Books on Sustainable Living

Canstar Blue – Energy Connection & Disconnection Fee Explained

Built Environment Sustainability Scorecard (BESS)

Building Sustainability Index (BASIX)

Greenpeace Green Electricity Guide

Make the Switch

Ecospecifier

Global GreenTag

Good Environmental Choice Australia (GECA)

Carpet Institute of Australia, Environmental Certification Scheme

Clean Energy Council Approved Solar Retailer

Nationwide House Energy Rating Scheme (NatHERS)

National Construction Code (NCC)

Tankulator - Rainwater Tank Calculator

Residential Efficiency Scorecard

Resilient homes | Queensland Reconstruction Authority

Your Resilient Home Guide (act.gov.au)

design-guidance-for-flood-resilient-homes.pdf (www.qld.gov.au)

Flood resilient home design guidelines (logan.qld.gov.au)

Bushfire Resilient Building Guidance for Queensland Homes | Queensland Reconstruction Authority (qra.qld.gov.au)

Design responses – Bushfire best practice guide (csiro.au)

How to build a fire resilient house - The Australian Museum

Resilient Building Council – Connecting People to a resilient future (rbcouncil.org)

Resilient Homes Program | NSW Government

An overview of the Resilient Homes Fund | Homes and housing | Queensland Government (www.qld.gov.au)

Rebate swap for solar and energy efficient upgrades | NSW Climate and Energy Action

Switch to solar | NSW Climate and Energy Action

Government programs | Clean Energy Council

Welcome to the Solar Homes Program | Solar Victoria

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Appendix A — Air conditioning systems

Wall hung single split systems or multi-split systems

Where such systems are installed, they must:

- Have an inverter compressor
- Have a refrigerant with GWP (Global Warming Potential) less than 750 e.g. R32
- Have the below minimum cooling or heating star rating depending on the Zoned Energy Rating Label (ZERL) zone, where the home will be located.

Rated cooling capacity	Zoned Energy Label Zone	Cooling Star rating	Heating Star rating
< 4 kW	Hot Zone	4	
	Average Zone	3	
	Cold Zone		2.5
≥ 4 kW and < 6 kW	Hot Zone	3.5	
	Average Zone	3	
	Cold Zone		2
≥ 6 kW	Hot Zone	3.5	
	Average Zone	3.5	
	Cold Zone		2

Ducted systems

Where such systems are installed, they must:

- Have an inverter compressor
- Have a refrigerant with GWP (Global Warming Potential) less than 750 e.g. R32
- Have the ability to zone different rooms
- Have the below minimum cooling or heating star rating depending on the Zoned Energy Rating Label (ZERL) zone, where the home will be located

Rated cooling capacity	Zoned Energy Label Zone	Cooling Star rating	Heating Star rating
< 10 kW	Hot Zone	3.5	
	Average Zone	3	
	Cold Zone		2
≥ 10 kW and < 13 kW	Hot Zone	3.5	
	Average Zone	3.0	
	Cold Zone		2
≥ 13 kW and < 16 kW	Hot Zone	2.5	
	Average Zone	2.0	
	Cold Zone		2
≥ 16 kW	Hot Zone	2.5	
	Average Zone	2	
	Cold Zone		2

Appendix B
TVOC limits

Paints, adhesives, sealants

Product category	TVOC limit (g/L)
Interior wall and ceiling paint, all sheen levels	16
Trim, varnishes, and wood stains	75
Primers, sealers, and prep coats	65
One and two pack performance coatings for floors	140
Waterproofing membranes and sealant	250
Structural glazing adhesive, wood flooring and laminate adhesives and sealants	100

Carpets

Compliance option	Test protocol	TVOC Limit (mg/m² per hour)
ASTM D5116	ASTM D5116 - Total VOC limit*	0.5
	ASTM D5116 - 4-PC (4-Phenylcyclohexene)*	0.05
ISO 16000 / EN 13419	ISO 16000 / EN 13419 - TVOC at three days	0.5
ISO 10580 / ISO/TC		
219 (Document N238)	ISO 10580 / ISO/TC	
219 (Document N238)	0.5	

Formaldehyde limits (engineered wood products)

Test protocol	Formaldehyde emissions limit
AS/NZS 2269:2004, testing procedure AS/NZS 2098.11:2005 method 10 for Plywood	≤1 mg/ L
S/NZS 1859.1:2004 - Particle Board, with use of testing procedure AS/NZS 4266.16:2004 method 16	≤1.5 mg/L
AS/NZS 1859.2:2004 - MDF, with use of testing procedure AS/NZS 4266.16:2004 method 16	≤1 mg/ L
AS/NZS 4357.4 - Laminated Veneer Lumber (LVL)	≤1 mg/ L
Japanese Agricultural Standard MAFF Notification No.701 Appendix Clause 3 (11) – LVL	≤1 mg/ L
JIS A 5908:2003- Particle Board and Plywood, with use of testing procedure JIS A 1460	≤1 mg/ L
JIS A 5905:2003 - MDF, with use of testing procedure JIS A 1460	≤1 mg/ L
JIS A1901 (not applicable to Plywood, applicable to high pressure laminates and compact laminates)	≤0.1 mg/m²hr *
ASTM D5116 (applicable to high pressure laminates and compact laminates)	≤0.1 mg/m²hr
ISO 16000 part 9, 10 and 11 (also known as EN 13419), applicable to high pressure laminates and compact laminates	≤0.1 mg/m²hr (at 3 days)
ASTM D6007	≤0.12 mg/m³ **
ASTM E1333	≤0.12 mg/m³ ***
EN 717-1 (also known as DIN EN 717-1)	≤0.12 mg/m³
EN 717-2 (also known as DIN EN 717-2)	≤3.5 mg/m²hr

* mg/m²hr may also be represented as mg/m²/hr.

** The test report must confirm that the conditions of Table 3 comply for the particular wood product type, the final results must be presented in EN 717-1 equivalent (as presented in the table) using the correlation ratio of 0.98.

*** The final results must be presented in EN 717-1 equivalent (as presented in the table), using the correlation ratio of 0.98.

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