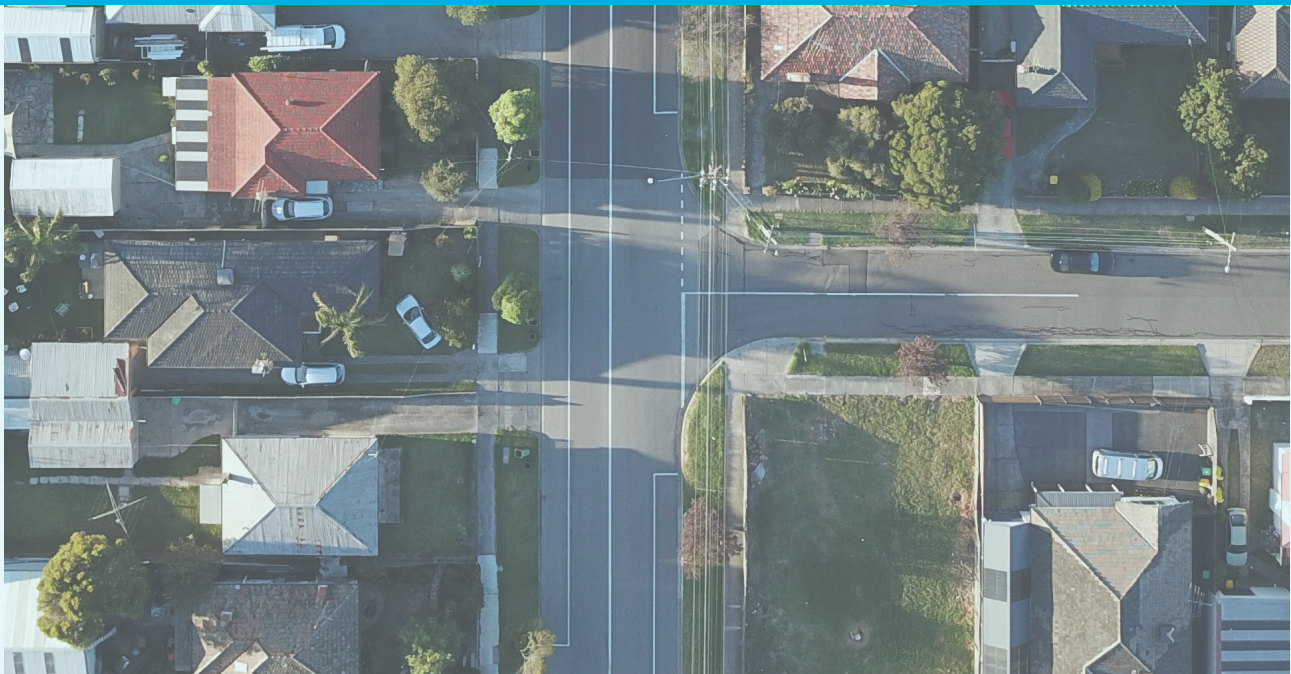




Defining zero carbon homes for a climate resilient future



Reducing emissions from homes will be critical for Australia to achieve its climate targets and secure a safe net zero future. Australia's 11 million homes are responsible for over 10% of Australia's total emissions and more than 25% of electricity consumption, and an additional 5.5 million homes are expected to be built before 2050.

The vast majority of Australian homes were built before the introduction of construction standards in the early 2000s. They are very inefficient in terms of energy consumption and thermal comfort.

Transforming Australia's housing stock and ensuring that new homes and existing homes become highly efficient and zero carbon is a necessary part of the transition to a net zero future.

This requires defining what a zero carbon home looks like in practice. A clear definition of a zero carbon building is critical to inform policy makers, lenders, the construction industry and households in the transition to Australia's zero carbon future.

What is a zero carbon building?

Zero carbon buildings produce no net emissions over their entire lifecycle. To achieve this, all decisions made at each design phase reduce energy demand and carbon emissions. There is no single solution: Zero carbon buildings are the product of many choices based on local climate conditions.

A zero carbon building has all of the below:

- + **PLANNING AND DESIGN DECISIONS** for location, construction, future maintenance and renovations to maximise a building's longevity and long-term safety for occupants, including prioritising resilience (i.e. ability to withstand or quickly recover from power outages and extreme weather events such as prolonged heatwaves, bushfire, cyclones, droughts, floods)

AND

- + **FORM** (i.e. building's orientation to the sun, overall shape, and arrangement of internal rooms) designed to suit local climate temperatures and harness renewable energy, sized to be an efficient use of space and materials, and able to be maintained safely

AND

- + **THERMAL SHELL** (i.e. external walls, ground floor and roof) designed, constructed and upgraded using a fabric-first approach to reduce the amount of energy needed to heat, cool and operate the building, therefore reducing the size of appliances needed to maintain safe indoor temperatures and air quality

AND

- + **MATERIALS** (i.e. all components used in a building plus its external spaces and structures on site) have low overall embodied energy and carbon emissions (meaning the energy used and emissions released to produce or dispose of building materials, and construct, upgrade or demolish a building), calculated over their lifecycle, or are reclaimed materials, and are durable

AND

- + **ELECTRIFIED APPLIANCES AND SERVICES** (i.e. fixed appliances) which are:

- > fully powered by renewable energy generated/stored on-site or purchased from a renewable energy source, and
- > optimised for a renewable energy grid (i.e. minimise energy demand and operable at times of peak solar generation)

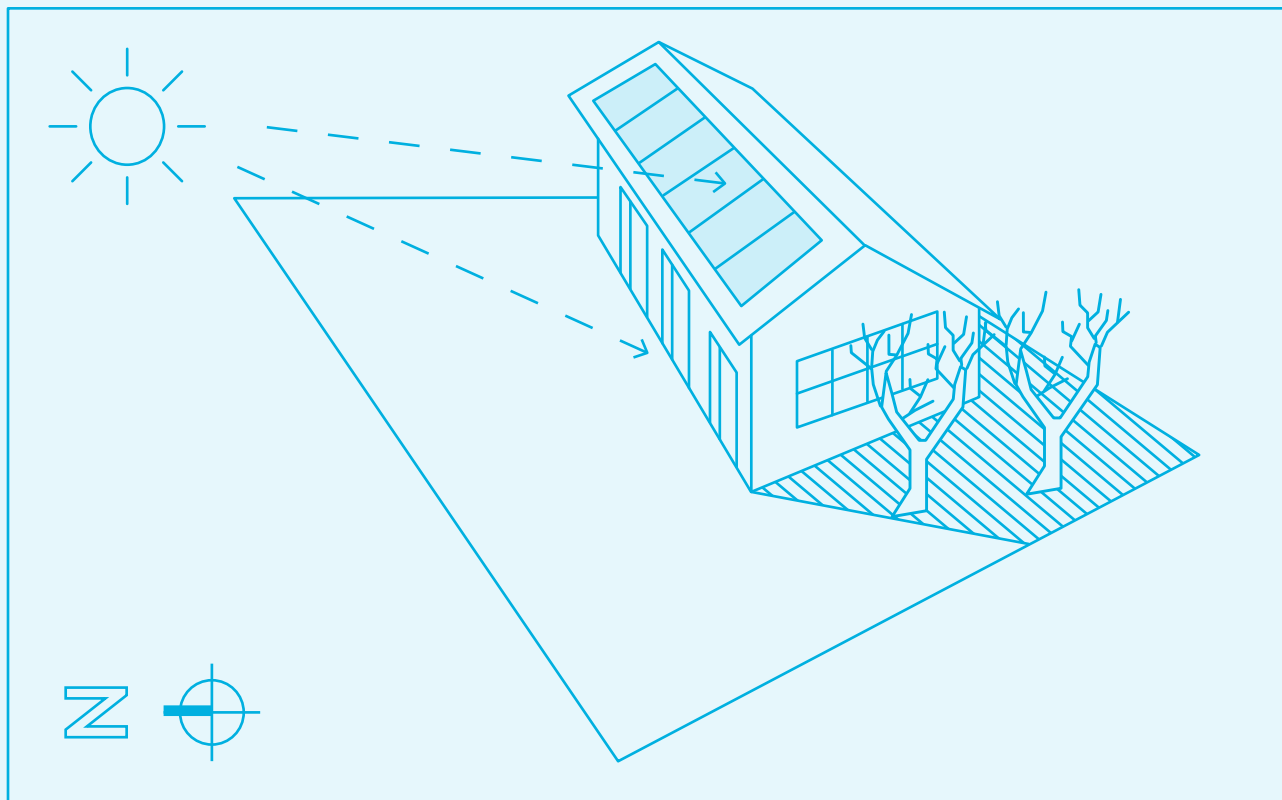
AND

- + **OPERATION** (i.e. control of building's features and fixed appliances) is simple and user-friendly on a day-to-day basis and for maintenance or repair by occupants, tradespeople or building managers.



Where to start to make a home zero carbon?

To achieve all the above for homes, it is necessary to ensure both new and existing buildings are made or improved using a strong focus on the four key elements: form, thermal shell, materials and appliances.



Form of a home can be optimised for its location

Residential buildings come in a range of shapes and types. Strategies to achieve zero carbon homes are dependent on several aspects: home type, size, shape and location or climate.

The size of the home should maximise energy efficiency for the number of occupants. Bigger homes require more resources to build, upgrade, and power. Australia has the largest homes in the world and they are growing. If floor areas are reduced, both embodied energy and operational energy demands will make it easier to achieve zero carbon from the outset.

The type of home (detached houses, townhouses, units and apartments) determines how much of the building form is exposed to the climate relative to the home's overall floor area, and ultimately heat losses and gains. This heat needs to be controlled to provide safe indoor temperatures throughout the year while minimising energy demand.

Thus the shape of a home should reflect its location and climate, by capturing and storing winter sun, rejecting hot summer sun, and harvesting renewable energy. This involves considering the depth or width of the building plan, positioning and size of windows and roof overhangs.

Overall, the form should be optimised for natural ventilation, daylight, and passive heating and cooling through prioritising the building's ability to accept or reject the sun's heat, planning the internal layout to maximise these benefits.

Some examples include:

- + In multi-storey homes, locating living areas above bedroom spaces as heat rises and occupants will need less energy to have a good night's sleep.
- + Avoiding high moisture spaces (bathrooms, kitchens, laundry) in spaces without external windows that can open, as trapped moisture increases the energy needed to keep occupants cool in summer and warm in winter.
- + Eliminating details which are difficult to insulate, make watertight or airtight.
- + Ensuring all materials are correctly installed according to modelling simulations and/or manufacturer's and design specifications.

Thermal shells need a fabric-first approach to minimise heating and cooling demands



A fabric-first approach is critical to achieving zero carbon homes. Fabric first means prioritising the thermal performance of the external walls, floor and roof to minimise heating and cooling energy demand ahead of considering the use of mechanical or electrical building services systems. For existing buildings this means prioritising repairs and upgrades ahead of 'add-ons' such as solar panels.

Using a fabric-first approach, the thermal shell is designed to significantly reduce overheating and loss of cool air in summer, as well as retain warmth in winter, thus reducing the size of heating and cooling appliances needed to stay safe and comfortable all year round.

Efficient thermal shells are essential to facilitating full electrification of the housing stock and transitioning to renewable electricity at the lowest infrastructure costs possible for society.

An efficient thermal shell reduces overall energy demand of the home, therefore reducing the strain on electricity networks and the grid. This is especially important at peak demand times and when there is a mismatch between electricity generation and times of peak demand. Energy efficient homes will help 'flatten' the energy demand of the home and reduce likelihood and vulnerability to power black outs. Ultimately, this reduces the scale of investment needed to upgrade electricity transmission and distribution networks.

The thermal shell's junctions (where walls meet floors and roofs) should be airtight, and openings (windows, doors and vents) should be airtight when closed, to ensure the shell performs to energy-efficient specifications, with all materials correctly installed, safely built providing low maintenance to either passivhaus standards or so that occupants can open and close up the building according to weather conditions.

The fabric-first approach maximises energy efficiency by controlling the three types of heat flows (radiant, conduction and convection) that move through a building, which is a crucial aspect of zero carbon homes (see Table 1).



Building materials have low or zero embodied energy



Materials contained in the site (yards and driveways, the thermal shell, and the interiors) need to be predominantly materials with low embodied energy overall, or reclaimed and from sustainable sources. They should also store carbon, such as timber structures and cladding. Durability is considered from the perspective of resistance to water or UV damage, as well as human impact in areas prone to high wear and tear, over the whole lifespan of the materials.

Materials used provide resilience after and during events such as flooding (resists water and can be cleaned-up and dried-out easily without distortion), bushfires (resistant to combustion and does not aid fire spread), and cyclones (fixed down to resist both upward and downward high wind pressures).

Efficient electrified appliances and services



Once the thermal shell is energy efficient, all appliances need to be efficient and electrified (including appliances for heating, cooling, and providing hot water), with appliances automated for use when renewable energy generation is plentiful during daylight hours. If thermal shells are insulated and air-tight, any pre-warming or pre-cooling delivered by energy efficient appliances will be retained over the course of the day and night. Appliances can be zoned to cool or heat different rooms to different settings and to only service rooms in use.

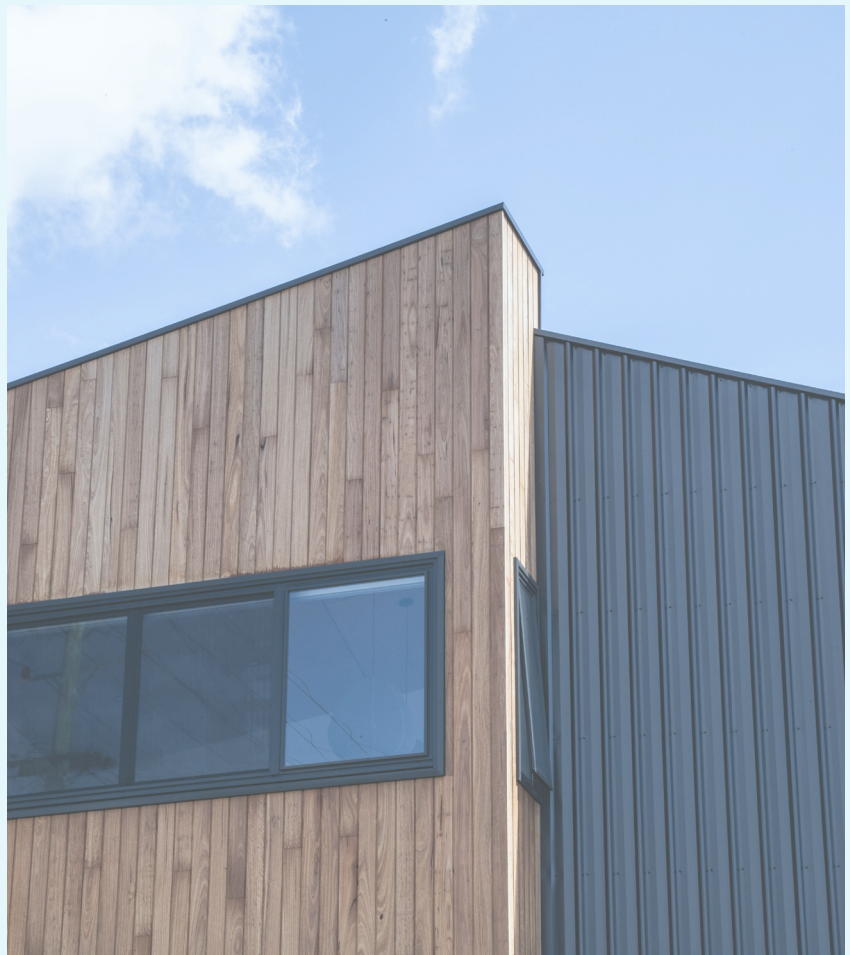




Table 1. How to apply zero carbon design to homes

Characteristics of a zero carbon thermal shell

| Heat gain types | External walls | Roof | Ground floor | External surfaces around the home |
|--|---|---|--|---|
| <p>1. Control sun's radiant heat hitting buildings and surrounding surfaces</p>  | <ul style="list-style-type: none"> + Light coloured walls to reflect sunlight. + Windows are shaded from summer sun with deciduous trees, retractable fabric shading devices, external louvres/ shutters, or roof overhangs. + Walls are fully insulated and can have high thermal mass (e.g. materials that absorb and store heat and release heat during cooler nights). | <ul style="list-style-type: none"> + Light coloured, reflective finishes or roof gardens. + Pitch optimised for rooftop solar panels. + Rooflights on only south facing roofs. | <ul style="list-style-type: none"> + Perimeter edges and internal surfaces are not exposed to summer sun. | <ul style="list-style-type: none"> + Hard surfaces (e.g. driveways) are minimised and shaded using planting, verandahs or similar, especially on north and west sides. |

| | | | | |
|---|--|--|--|---|
| <p>2. Control the conduction of heat through the thermal shell</p>  | <ul style="list-style-type: none"> + Walls and window frames are fully insulated, and are 'thermally broken' (e.g. outer and inner layers are separated with an insulated gap). | <ul style="list-style-type: none"> + Ceilings are insulated from roof structure or other dwellings above. + Roof materials and structure are thermally broken. | <ul style="list-style-type: none"> + Lowest floor is insulated if continued externally, (e.g. outdoor dining, entrances, driveways) + Floors are thermally broken. | <ul style="list-style-type: none"> + n/a |
|---|--|--|--|---|

3. Control heat gains through convection.



- + Walls and junctions are air-tight, including doors and windows.
- + Glazed areas are argon filled double or triple glazing, sized for daylight needs.
- + In hot climates, internal walls use materials that absorb heat (e.g. brick).
- + Security or fly-screens to vent heat at night.
- + Ceilings are air-tight, and all penetrations through ceilings are sealed.
- + Vent humid air to outside, with heat recovery in colder climates.
- + Floors are airtight including gaps between skirting boards and flooring.
- + Any exposed materials with a high thermal mass (e.g. materials that absorb heat but remain cool to touch) are located above floor insulation to absorb excess internal heat.
- + Shade or use deciduous planting on external spaces to north and west to pre-cool air around the home and reduce convection heat gains when external doors are opened.
- + Air supply to air-con appliances.





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