HOUSE DESIGN FOR TEMPERATE CLIMATES

Designing dwellings to reduce energy use

Temperate climates provide an ideal environment for low-cost and effective design measures to reduce or even eliminate the need for heating and cooling residential buildings, thus minimising energy consumption and cost. This Building Technology Resource provides tips on the most effective design solutions for temperate climates.

Most people in Australia live in a mild to warm temperate climate. Australia's National Construction Code divides the country into eight climate zones, each with its own distinct climate profile. Zone 5 (warm temperate) and zone 6 (mild temperate) stretch from the south-west corner of Western Australia, along the south coast, and up into New South Wales and the southern Queensland hinterland (Figure 1).

The main characteristics of climate zones 5 and 6 are:

- low to moderate difference in temperature between day and night near the coast; high difference inland
- four distinct seasons: summer and winter tend to exceed human comfort range, while spring and autumn are ideal for human comfort
- mild to cool winters, with low humidity
- hot to very hot summers, with low to moderately high humidity
- highly variable access to sunlight, direction of cooling breeze, and wind patterns.

Major population areas within these climate zones include Perth, Adelaide, Geelong, Melbourne, Sydney, Newcastle, Wollongong, Port Macquarie and Toowoomba.

In these areas, very little heating or cooling is generally required in a well-designed house during spring and autumn. However, summers are often very hot, and extended heat waves can be challenging for even the best designed house. Houses in warm temperate areas (zone 5) often experience moderately high humidity in summer.

Winters can also be challenging, especially in mild temperate areas (zone 6). Often houses in these areas consume more energy through winter heating than through summer cooling, so designing for winter warmth is the priority.

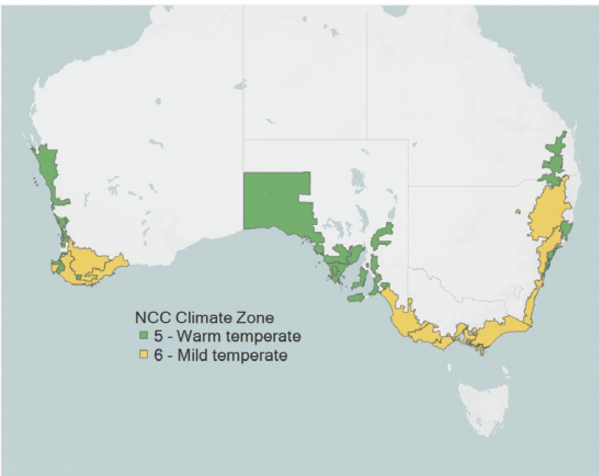

FIGURE 1 Temperate climate zones of Australia. (© 2021 Mapbox and OpenStreetMap)

DESIGN CONSIDERATIONS FOR TEMPERATE CLIMATES

Understanding average temperature ranges throughout the year is a good first step in determining what design elements to consider when building in each climate zone. Current and historical weather data are available on the Bureau of Meteorology website.

Mild temperate areas (such as Melbourne and Warrnambool) have cold winters and relatively mild summers, while warm temperate coastal areas (such as Perth and Adelaide) have cool winters, but can experience very hot summers (Figures 2, 3). Although the inland city of Toowoomba is further north than Sydney, Adelaide and Perth, it experiences cooler winters; even its average summer maximum temperature is lower than that of Perth. This demonstrates the impact that elevation can have on climate: Toowoomba sits on the crest of the Great Dividing Range, ~700 m above sea level.

When designing houses in temperate areas, such as zones 5 and 6, it is useful to consider the following design elements.

ORIENTATION

The aim in temperate climates is to strike the right balance between capturing winter sunshine and protecting from summer

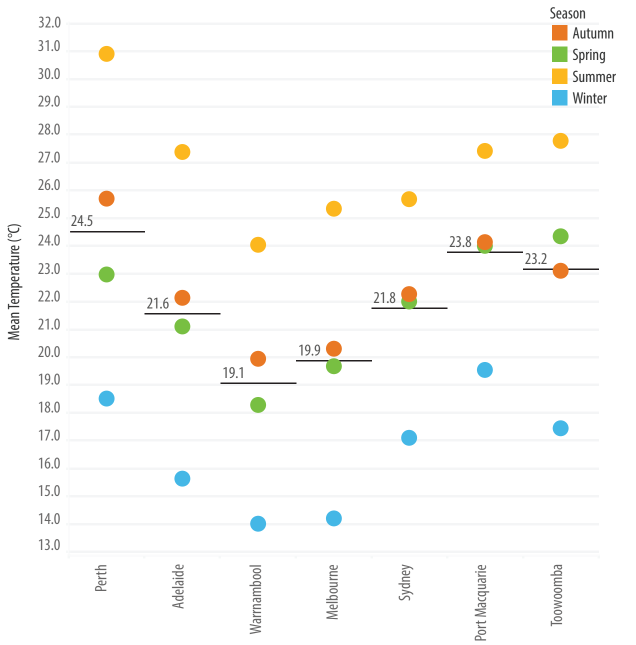

FIGURE 2 Average seasonal maximum temperatures for main cities in climate zones 5 and 6.

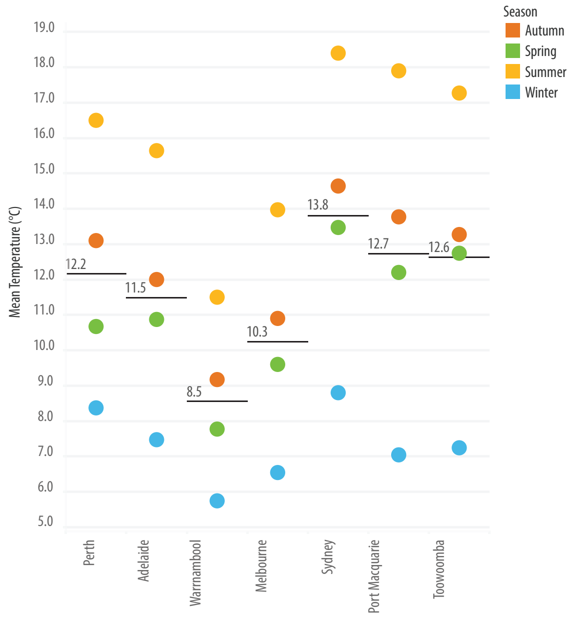

FIGURE 3 Average monthly minimum temperatures for main cities in climate zones 5 and 6.

FIGURE 4 North-facing glazing allows winter sun into the building. (Michael Ambrose)

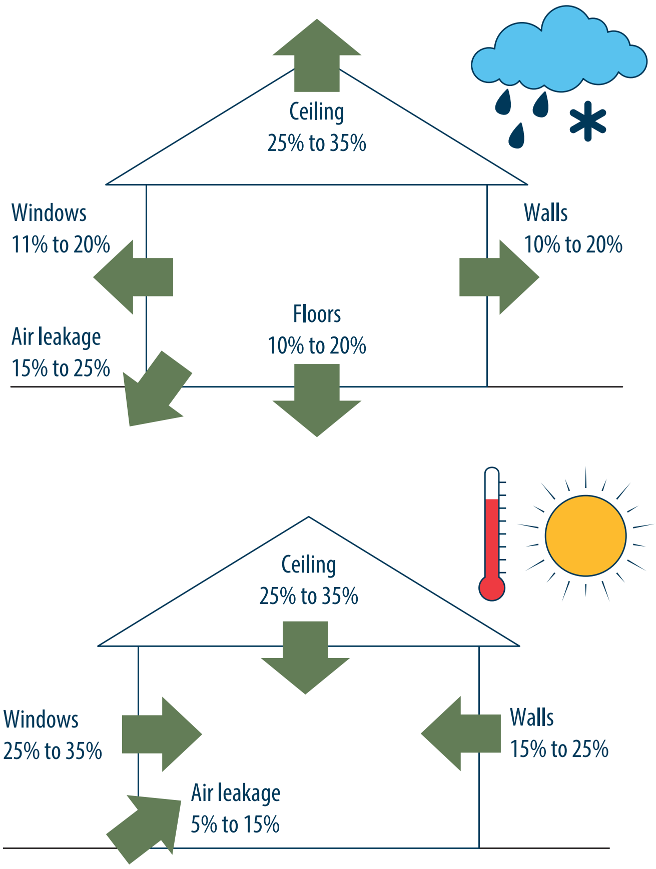

FIGURE 5 Uninsulated elements contribute to heat loss and gain in buildings.

heat. Adopt principles of passive design, which takes advantage of the climate to maintain comfortable indoor temperatures. Locate living areas and family rooms on the north side, with bedrooms and service areas on the south side. The house should also be designed to allow for cross-ventilation. This is especially important during the summer months, but can also help to distribute heat throughout the house in winter.

WINDOWS

Windows are essential for letting sunlight in, but they are also a major source of heat loss and gain in residential buildings. Careful planning of window areas is critical. Avoid overuse of glazing: in each room, ensure that the ratio of total window area to total floor area does not exceed 0.25. Maximise the use of north-facing glazing, while minimising the use of east- and west-facing glazing (Figure 4).

In cooler areas (zone 6), consider using double glazing with a high solar heat gain coefficient (SHGC) and low U-value. These values describe the amount of solar radiation that penetrates the window, and the conductivity of the entire window (glass plus frame), respectively. Ideally, this glazing should be combined with thermally broken window frames, which break the path of thermal conductivity between the inside and the outside of the frames.

In winter, window treatments such as heavy drapes with pelmets reduce heat loss overnight. In summer, window shades protect against the sun. Many cold winter areas have hot summers, so carefully designed, passive shading systems are essential.

INSULATION

Well-insulated houses reduce heat loss to the outside in winter and reduce heat gain in summer. A well-insulated ceiling is essential to reduce heat loss in winter and to restrict the flow of heat from a hot roof space into living spaces in summer. Because heat can escape through walls and floors, these areas should also be insulated (Figure 5).

Bulk insulation batts are the most common material for insulating walls and ceilings, and they are simple and cost effective to install. Insulating external walls is essential and easy in new houses, but can be more difficult in existing houses. Use thick layers of bulk insulation in ceilings and line the underside of roofing material with inward-facing reflective foil. The thickness of wall insulation will probably be limited by the amount of space available. Buildings with a single-skinned wall system, such as rammed earth or mud brick, should be insulated on their external face.

If using a raised floor (concrete or lightweight), insulate under the floors with materials such as spray-on or rigid panel insulation.

SEALING

Australian houses are relatively ‘leaky’, allowing air to enter or exit internal spaces – for example, through gaps around poorly sealed

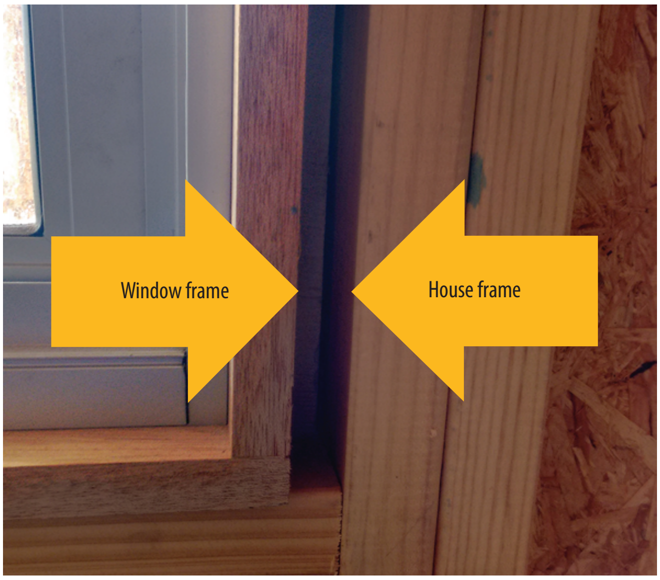

FIGURE 6 Unsealed gaps between windows and house frames let air pass through. (Michael Ambrose)

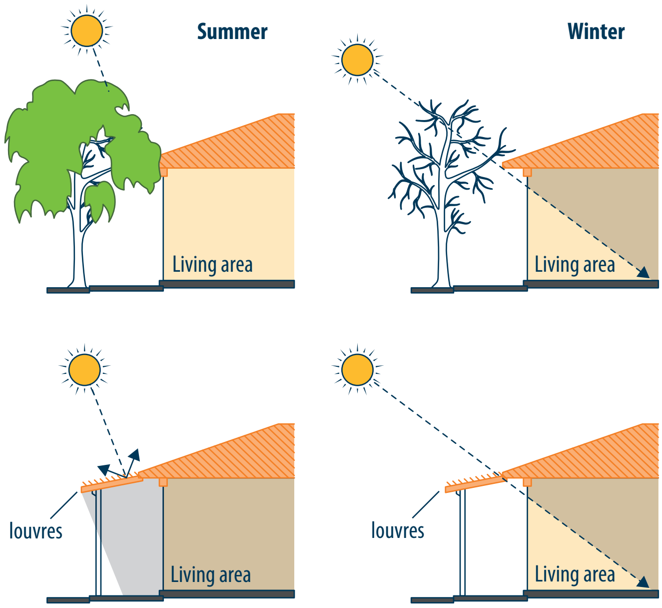

FIGURE 7 Summer and winter shading options.

windows and doors, downlights and exhaust fans. These gaps allow conditioned air to escape and cold air to blow in.

Well-sealed houses reduce the loss of warm air (and the gain of cold air) and thus the energy required to heat internal spaces. Ensure that windows and doors use high-quality weather stripping and that frames are sealed against the house frame (Figure 6). Infiltration testing is a good way of discovering leaks, so they can be rectified. Very tightly sealed houses often need to incorporate an active heat recovery ventilation system to ensure that indoor air quality is maintained while reducing heat loss through the ventilation system.

In summer, well-sealed houses need to be able to be opened up to allow natural ventilation, especially overnight when you can take advantage of cooler temperatures. Ventilation systems can usually be operated to bring in cool air from outside at night; they also allow the home to be closed up on very hot days, to protect against overheating.

SHADING

During summer, temperate areas can experience very hot conditions. Protecting walls and windows from direct sunlight will help reduce heat gain. Shading can be achieved through the use of fixed shading systems, such as awnings, window shutters and pergolas, or landscaping with deciduous trees, vines and creepers. Careful design is important to allow winter sun to reach the building. Adjustable slats or louvres on window shutters and pergolas can allow the lower-angled winter sun through while blocking the higher-angled summer sun (Figure 7). Deciduous plants block summer sun with their leaves, but let winter sun through once they lose their leaves. Extendable awnings can provide summer shade and then be retracted to allow winter sun in (Figure 8).

Eaves also help to shade windows in summer while allowing winter sun in. The optimal width of the eave depends on the latitude, but generally an eave width of at least 450 mm is good for northern temperate areas, while 600 mm width eaves are better in southern areas.

HEATING AND COOLING SYSTEMS

Most houses in mild temperate areas (zone 5) require a heating system to maintain a comfortable internal environment. In many of these areas, heating is traditionally provided through natural gas-fired systems, either ducted or wall-mounted. However, these system are generally less efficient than modern heat pump reverse cycle systems, which can deliver both heating and cooling in a single unit. Evaporative coolers, which cool the air to just above the wet bulb temperature, can be used where summer humidity is usually low but are significantly less effective where humidity is high.

FIGURE 8 Extendable awnings provide summer shade. (Michael Ambrose)

In warm temperate areas (zone 6), a well-designed house may require no heating or cooling system at all. In these areas, fans may be all you need to provide a cooling effect. Just by circulating air, they can improve comfort to a level similar to reducing the temperature by ~3°C. They are also inexpensive to buy and run. Fans are a good solution for summer cooling in mild temperate climates, too.

THERMAL MASS

Unlike insulation, which restricts heat transfer, thermal mass absorbs and stores heat energy. This can be an effective mechanism for capturing winter heat from the sun via a tiled or concrete floor that then radiates stored heat back into the house at night. However, thermal mass must be designed and used carefully: excess or uninsulated thermal mass can soak up heat from your heating system and transfer it outside or into the ground. During summer, the thermal mass in external walls can help to reduce heat gain in interior spaces by absorbing heat during the day and then radiating it to cooler outside areas at night.

CONDENSATION

Cold surfaces are conducive to the build-up of moisture from warm air in the room. Areas where water vapour is released into the air in large quantities as the result of normal activities – such as cooking, running dishwashers, showering, and using unvented clothes dryers or unflued heaters – are particularly prone to condensation. Even occupants' breathing increases the amount of water vapour.

For some materials, occasional wetting by condensation is not problematic. However, excessive condensation can foster the growth of moulds, which may damage building materials, reduce indoor air quality and risk occupants' health.

Good ventilation and heat recovery ventilation systems, for example, can be used to minimise, or even avoid, condensation.

MORE INFORMATION

Additional information can be found in the following resources. Please check your local authorities for specific legislation, codes and guidelines, as they can vary between states and territories.

Australian Building Codes Board (2019) National construction code. Canberra: Australian Building Codes Board

Australian Greenhouse Office (2006) Global warming – cool it! A home guide to reducing energy costs and greenhouse gases. Canberra: Department of the Environment and Heritage

Aynsley R (2014) Natural ventilation in passive design. EDG 80 RA. Melbourne: Australian Institute of Architects

Bureau of Meteorology (2021) Climate statistics for Australian locations. Canberra: Bureau of Meteorology. <www.bom.gov.au/climate/data/index.shtml>

Cole G (2011) Residential passive design for temperate climates. EDG 66 GC. Melbourne: Australian Institute of Architects

Wright J, Osman P, Ashworth P (2009) The CSIRO home energy saving handbook. Sydney: Pan Macmillan Australia