HOUSE DESIGN FOR COLD WINTER CLIMATES

Designing dwellings to minimise heat loss

In many parts of Australia, winter heating incurs the biggest residential energy cost. In these areas, it is important to design dwellings that retain heat and minimise heat loss to the outside. This Building Technology Resource provides tips on the most effective design solutions for cold winter climates.

Cold winter areas in Australia are found not just in sparsely populated alpine areas; many populated areas also experience subzero temperatures overnight and may reach only single-digit temperatures during the day. Australia's National Construction Code divides the country into eight climate zones, each with its own distinct climate profile. Zone 7 (cool temperate) and zone 8 (alpine) are the areas that tend to experience cold winters (Figure 1).

The main characteristics of these two climate zones are:

- low humidity
- high difference in temperature between day and night
- four distinct seasons: summer and winter tend to exceed human comfort range, while spring and autumn have highly variable conditions (which increase in range with climate change)
- cold to very cold winters, with zone 8 receiving significant rainfall and some snow (although climate change is causing precipitation to decrease and temperatures to increase)
- warm to hot, dry summers (occurring more often in response to climate change).

Major population areas within these climate zones include: Hamilton, Ballarat, Bendigo and Shepparton in Victoria; Bathurst, Cooma and Armidale in New South Wales; all of Tasmania; and the Australian Capital Territory.

FIGURE 1 Cool temperate (blue) and alpine (white) climate zones. (© Commonwealth of Australia 2020. Your Home is licensed under CC BY 4.0, and provided free of charge at www.yourhome.gov.au)

DESIGN CONSIDERATIONS FOR COLD CLIMATES

Achieving thermal comfort in winter requires more energy in cold climate areas than in other parts of Australia. 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.

In climate zones 7 and 8, areas on or near the coast (such as Hobart and Launceston) experience a narrower range of monthly minimum temperatures than inland areas (Figure 2). Alpine and subalpine areas (such as Mount Buller and Cooma) experience subzero minimum temperatures throughout winter. Many inland areas have high minimum temperatures (>10°C) during the summer, which are coupled with hot to very hot summer maximum temperatures (>35°C).

When designing houses in cold winter areas, such as zones 7 and 8, it is useful to consider the following design elements.

ORIENTATION

Capturing winter sunshine helps to warm a house naturally. Adopt principles of passive design, which takes advantage of the climate to maintain comfortable indoor temperatures (Figure 3). Locate living areas and family rooms on the north side, with bedrooms

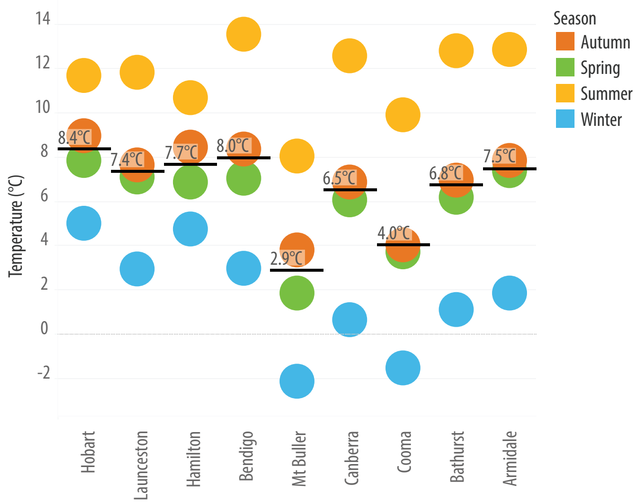

FIGURE 2 Average seasonal minimum temperatures for locations within climate zones 7 and 8.

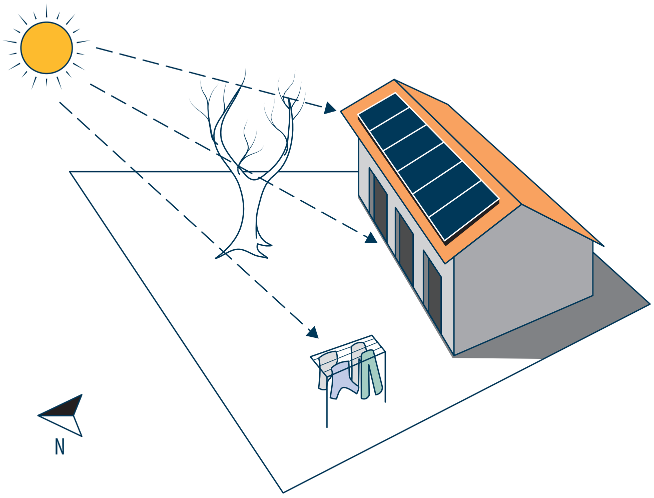

FIGURE 3 Passive design principles harness the climate to keep indoor areas at comfortable temperatures.

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 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).

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. Heat rises, so a well-insulated ceiling is essential. However, heat can also escape through walls and floors, so these areas should be insulated (Figure 5).

Bulk insulation batts are the most common way to insulate 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. Check your ceiling space to confirm total insulation coverage, as tradespeople may have removed and not replaced insulation, leaving gaps in coverage. 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. If using a concrete slab, consider insulating around the slab edges. In cases where in-slab heating is used, it is essential to insulate the bottom of the slab to reduce heat loss to the ground.

SEALING

Australian houses are relatively 'leaky', allowing air to enter or exit internal spaces – for example, through gaps around poorly sealed windows and doors, downlights and exhaust fans. These gaps allow conditioned air to escape and cold air to blow in.

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

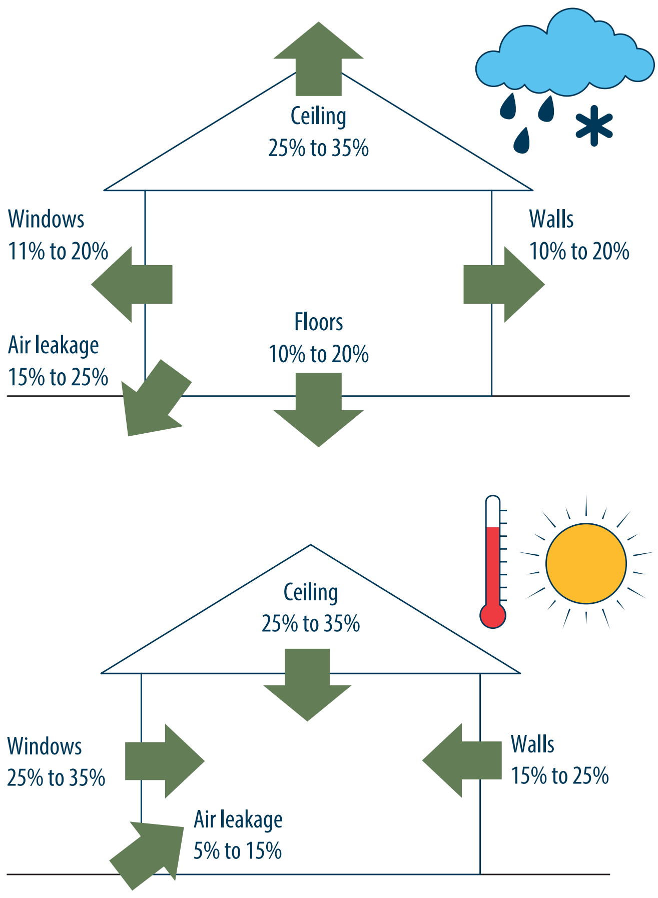

FIGURE 5 Uninsulated elements contribute to heat loss and gain in buildings.

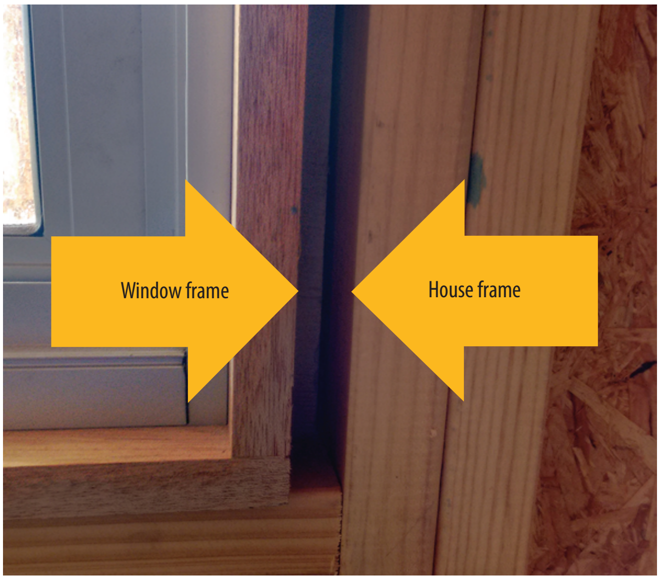

FIGURE 6 Unsealed gaps between windows and house frames let air pass through. (Michael Ambrose)

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.

HEATING

Virtually all houses in climate zones 7 and 8 require some form of heating to maintain a comfortable internal environment. In these areas, heating is traditionally provided through ducted or wall-mounted gas-fired systems. However, these systems are generally less efficient than modern high-efficiency reverse-cycle air conditioners (also called heat pumps). Well-designed active solar energy systems with heat-storage capacity are the most efficient heating options, but they can be expensive.

Open fireplaces and slow-combustion heaters may look nice, but they are an inefficient way to heat a house. Up to 90% of the heat energy produced in an open fireplace goes up the chimney, which draws in cold air in the process; slow-combustion heaters lose 30–40% of heat energy up the flue. Fireplaces also release high amounts of air pollution to the local environment and, if poorly vented, can lead to poor air quality inside the house. Regulations require that new fireplaces must have closeable dampers, which can be retrofitted to existing fireplaces.

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.

SPECIAL WINTER CONSIDERATIONS

In alpine areas of Australia, subzero temperatures during winter are common. The design of houses in these climates must take into account particular issues that are not as common in other areas.

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.

Condensation in roof spaces deserves special mention, particularly if the roof sheeting is metallic. Condensation that drips from the underside of the sheeting can be troublesome at any time, but the problem is aggravated if the roof space is ventilated inadequately or if the pitch of the roof is low (<25 degrees). Installing sarking under the roof and providing adequate ventilation to the roof space should reduce condensation. A vapour barrier between the ceiling sheeting and the ceiling joists will reduce the transmission of water vapour into the roof space.

VAPOUR BARRIERS

Vapour barriers create an impervious membrane between indoor and outdoor surfaces. Materials commonly used as vapour barriers include polyethylene, bituminous felts, and lapped and sealed foil laminates.

PLUMBING PROTECTION

In cold temperatures, the water in pipes and tanks can freeze and fracture them. It is therefore unwise to fix plumbing externally to walls, or to leave pipes and tanks unprotected in roof spaces. Locate pipes within the underfloor space and insulate pipes and tanks in roof spaces to prevent water freezing inside them.

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

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

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