VENTILATION OF BUILDINGS

Natural and mechanical ventilation for residences

This Building Technology Resource discusses how ventilation is used, why it is necessary, and the methods that are most suitable for different circumstances.

Ventilation is used in residential buildings for several reasons: to regulate indoor temperature for comfort; to replenish oxygen for occupants to breathe; to remove odours or other pollutants; and to control humidity and condensation. Ventilation is a key element of building design and is closely related to indoor air quality and condensation.

Most residential buildings in Australia use natural (non-mechanical) ventilation, whereas most commercial buildings use mechanical (fan-forced) ventilation. Australia's National Construction Code (NCC) sets out building performance requirements and advises on solutions that are deemed to satisfy those requirements. In the case of ventilation, a space used by occupants must be ventilated with outdoor air that will maintain adequate indoor air quality. A building would be deemed to satisfy this performance requirement if the rooms occupied by a person for any purpose had either:

- natural ventilation to outdoor spaces, through openings such as windows and doors that had an openable size of at least 5% of the room's floor area
- a mechanical ventilation or air-conditioning system that complied with relevant Australian Standards.

Other solutions might also be deemed to satisfy the NCC. The performance requirements were originally based on the need to control odours generated by occupants, with the aim of satisfying 80% of occupants. In recent decades, however, it has become clear that there are other significant sources of contamination that can affect indoor air quality. Consideration of the meaning of adequate indoor air quality has led to more specific definitions that take into account health risks as well as occupant comfort. The NCC has responded by incorporating 'verification methods' for ensuring suitable indoor air quality, which list a range of indoor air pollutants and recommended limits on their concentration. These verification methods are not mandatory, but are intended to be useful in demonstrating compliance with the NCC's performance requirements.

METHODS OF VENTILATION

NATURAL VENTILATION

Natural ventilation is the non-mechanical ventilation of buildings with outdoor air. It requires openings in the external fabric of the building, such as windows and doors, that are adequately sized to allow sufficient air to flow through (Figure 1). Each habitable room in the building must have openings to the outside or, in some circumstances, to adjoining rooms with such openings (in accordance with the requirements for cross-ventilation).

Adequate natural ventilation can be incorporated into new buildings by:

FIGURE 1 Natural ventilation is the non-mechanical ventilation of buildings with outdoor air. (baona/istock)

- orienting the building to maximise its exposure to the prevailing summer wind direction
- designing a relatively narrow floorplan to facilitate the passage of air through the building
- locating openings in walls to facilitate the passage of air through the building
- using vegetation to modify the external wind direction, to enhance ventilation and to cool incoming air
- locating horizontal openings near floor level, which is more effective than vertical openings for ventilation purposes
- elevating rooms to catch stronger winds.

AIR INFILTRATION

Even when doors and windows are closed – for example, due to bad weather, noise or security concerns – a building will still be naturally ventilated (albeit at a reduced rate) by air infiltration, whereby air enters and leaves the building through cracks, gaps and other openings (Figure 2).

Air infiltration is driven by three main factors:

- the number and size of external gaps, cracks and other openings
- the strength and direction of external winds
- the difference between internal and external air temperatures.

Until the 1970s, Australian residential buildings typically included vents in external walls to ensure air infiltration. However, research indicated that enough air infiltrated homes even without vents, so their use ceased (except in specific situations, such as rooms with unflued gas heaters). Australian houses were considered 'leaky' because of construction methods that left gaps around windows

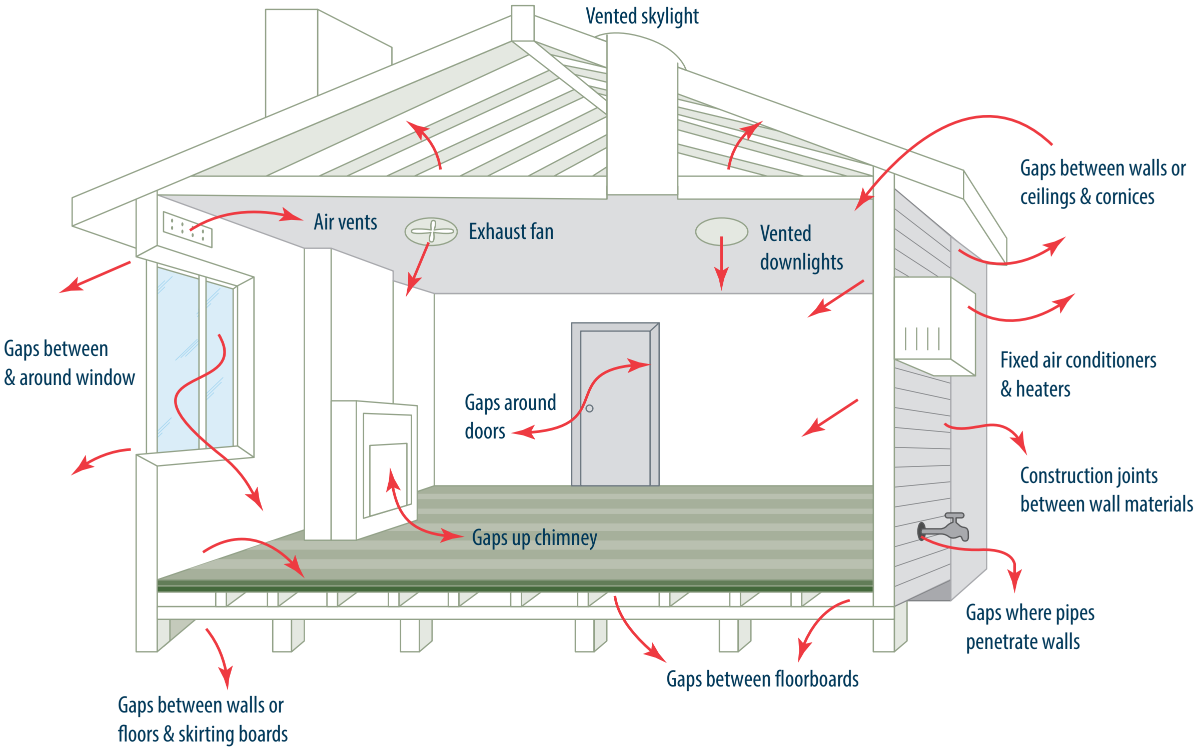

FIGURE 2 Common paths for the leakage of air into buildings.

and doors and in flooring. Since then, construction methods have changed in favour of conserving energy and improving building sustainability. A 2015 survey found that only one-third of houses up to 3 years old in capital cities would meet target 'tightness' levels for energy conservation, with others still highly leaky.

Today, there is much interest in using gap sealing to reduce the leakiness of buildings – and the associated energy costs and carbon emissions. However, reducing air infiltration may have consequences for indoor air quality and condensation. Gap sealing must therefore be accompanied by procedures to control ventilation while considering the impacts of condensation in buildings (for example, local exhaust of wet areas and of moisture-generating activities).

CROSS-VENTILATION

Some buildings – such as those with large floor areas – are more difficult to ventilate naturally, because internal rooms are farther from openings in the external fabric of the building. The NCC addresses the nexus between ventilation method and building size by allowing natural ventilation to come from an adjoining (ventilated) room, rather than the outside, via cross-ventilation.

In residential buildings, cross-ventilation is permitted if both the room to be ventilated and the adjoining room are within the same property and:

- the room to be ventilated does not contain a toilet
- the room to be ventilated has openings with a ventilating area of at least 5% of its floor area
- the adjoining room has openings with a ventilating area of at least 5% of the combined floor areas of both rooms (Figure 3).

Other building types may require larger openings, the recommended size of which may depend on the presence of ceiling fans or evaporative cooling.

For more humid climate zones, the NCC specifies additional requirements for the breeze paths between rooms. Air from the outside may traverse up to three rooms before exiting the building,

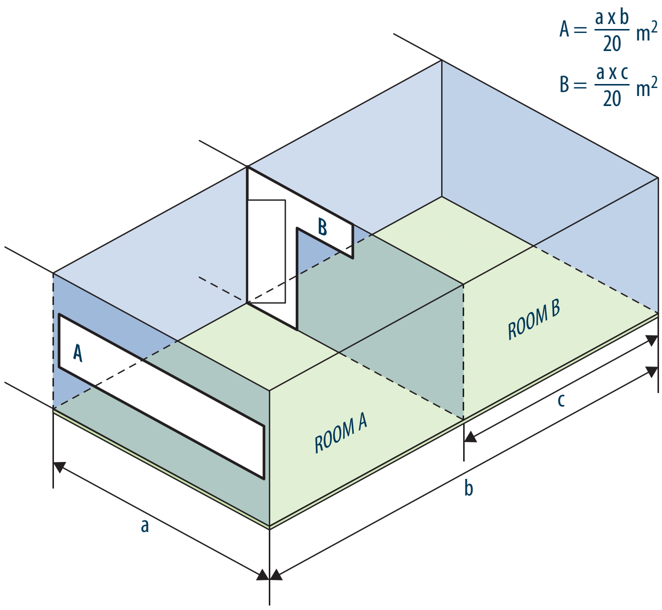

FIGURE 3 Method of determining areas of openings for cross-ventilation. (National Construction Code ©2019 Australian Building Codes Board, https://ncc.abcb.gov.au/)

but the breeze path must be no greater than 20 metres and pass through no more than two internal walls. Breeze paths and cross-ventilation are particularly important when the openings in a habitable room are closed or sealed shut (Figure 4).

Cross-ventilation is likely to become more important as construction in Australian cities begins to focus more on apartments than on detached housing.

MECHANICAL VENTILATION

Mechanical ventilation is the fan-forced introduction of air from the exterior of a building to its interior. Refrigerative air conditioning and central heating systems are fan-forced but are generally not considered mechanical ventilation, as they typically only recirculate treated indoor air.

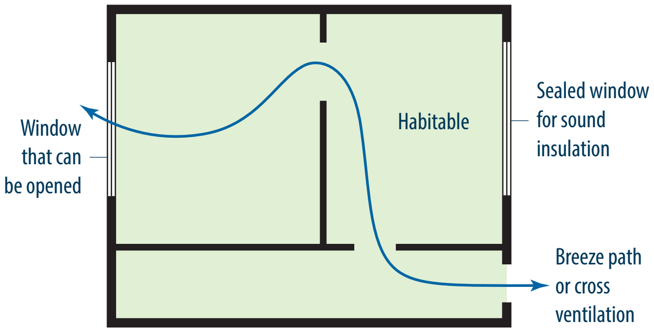

FIGURE 4 A possible cross-ventilation scenario.

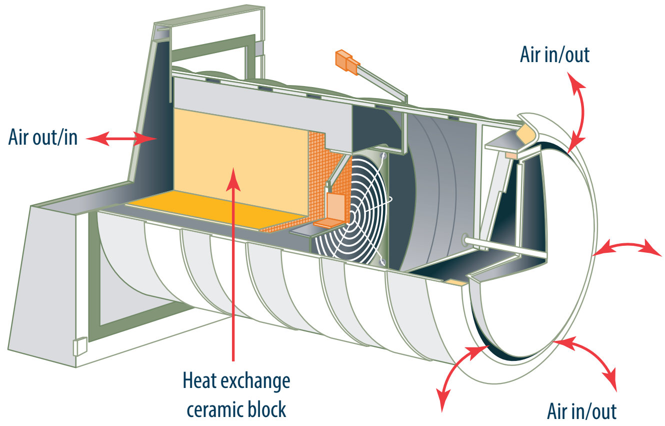

FIGURE 6 Wall-mounted heat recovery ventilation unit.

Although it incurs more installation and maintenance costs than natural ventilation, mechanical ventilation can be used in circumstances where natural ventilation is not viable or suitable – for example, in areas with high noise levels, privacy or safety concerns, high pollution levels or low wind velocity.

The NCC refers to mandatory Australian Standards for mechanical ventilation that are specified at the design and construction phases of a building. Thereafter, there are no requirements to check that ventilation specifications are maintained, and deviations from specification may become apparent only after occupants complain about poor indoor air quality. Building owners should undertake regular inspection to ensure that their mechanical ventilation systems:

- perform as required
- are adequately maintained (including changing filters, checking drainage, etc.)
- are redesigned, where necessary, to accommodate alterations in the number or location of building partitions
- are not blocked or hindered, such as by occupants interfering with air outlets to avoid draughts, which would hinder air distribution
- are upgraded, where necessary, to meet the requirements of increased occupancy levels.

HEAT RECOVERY VENTILATION

Increasing the ventilation in some parts of a building may appear to counteract the objectives of energy conservation. Heat recovery ventilation is a type of mechanical ventilation that offsets this effect by recovering the heat from outgoing air to minimise energy losses (Figure 5). It is ideally suited to tightly constructed housing in cold climates. Heat recovery ventilation systems should be designed by experts, because there is significant potential for poorly designed systems to create unwanted side effects.

Simpler and cheaper alternatives to whole-house heat recovery ventilation are often possible, depending on the situation. For example, a small ventilation unit can be installed in an external wall, much as external vents once were (Figure 6). These draw low power (under 3 W) and cycle air into and out of the building, transferring heat to and from a ceramic heat reservoir.

EMERGING TECHNOLOGIES

Many emerging technologies address building ventilation needs, including:

- hybrid ventilation, which controls the scheduling of natural and mechanical ventilation based on ambient climate
- solar chimneys, which use solar radiation to heat air inside outdoor shafts to building interiors, thus inducing air movement by a stack effect
- displacement ventilation, which introduces cooler air at lower levels of a building interior to displace and exhaust warmer air at higher levels
- evaporative cooling chimneys, which uses wind pressure to push warm air at the top of the chimney across a water spray or a saturated fabric, causing evaporative cooling of the air before it reaches the building interior.

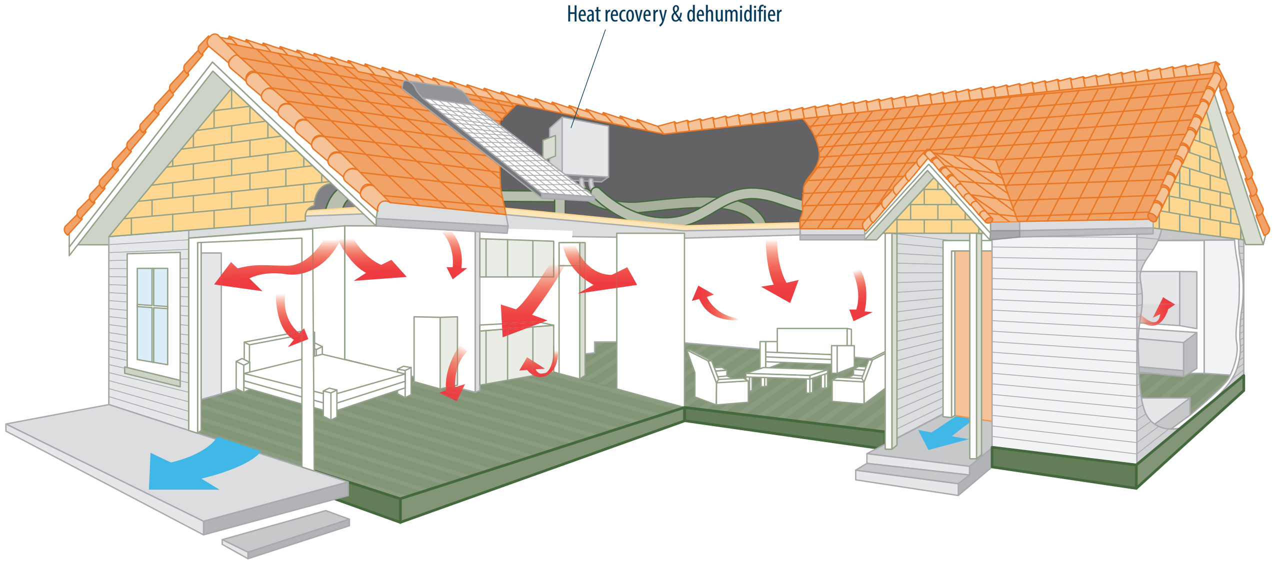

FIGURE 5 A heat recovery ventilation system used in tightly sealed housing.

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.

Ambrose M, Syme M (2015) House energy efficiency inspections project. Canberra: CSIRO

Australian Building Codes Board (2016) National construction code. Canberra: Australian Building Codes Board

Australian Building Codes Board (2018) Indoor air quality. 2nd ed. Canberra: Australian Building Codes Board

Australian/New Zealand Standard AS/NZS 3666.1:2011 Air handling and water systems of buildings – Microbial control. Part 1: Design, installation and commissioning

Australian Standard AS 1668.2-2012 The use of ventilation and airconditioning in buildings. Part 2: Mechanical ventilation in buildings

Aynsley R (2014) Natural ventilation in passive design. Environment Design Guide 80 RA. Melbourne: Royal Australian Institute of Architects

Department of the Environment and Energy (2017) Your home. Canberra: Australian Government. <www.yourhome.gov.au>