A proposed airtightness target for New Zealand dwellings

Based on research, BRANZ recommends building new houses and apartments to an optional target of three air changes per hour at 50 pascals pressure (3 ach @ 50 Pa), with whole-dwelling mechanical ventilation installed to address underventilation. To keep costs down, this target could be achieved by introducing changes to common construction details and monitored with optional performance testing. If the requirements for thermal efficiency in the New Zealand Building Code are upgraded in future, changes to the ventilation and airtightness requirements should be considered at the same time. More performance testing is also encouraged.

There is ongoing discussion about whether there should be a target level of airtightness for our buildings in New Zealand.

Previous BRANZ measurements show that airtightness in houses has already increased significantly since the 1960s without a specific requirement in the Building Code. But the evidence from overseas suggests that regulation changes, coupled with testing and education schemes, are the most effective way of changing the airtightness in our building stock.

The airtightness of a dwelling is important because this affects the building's energy efficiency and its ability to maintain a comfortable, draught-free indoor environment.

Airtightness in existing dwellings

Modern houses and apartments typically achieve 4–5 ach @ 50 Pa (a measure of airtightness at an elevated pressure inside the dwelling) (Figure 1). However, the spread of observed airtightness ranges between 0.5 and 10 ach @ 50 Pa, depending on the construction and the detailing used to seal gaps.

A significant contributor to the improvement in envelope airtightness around 1960 (Figure 1) was the shift from suspended tongue and groove flooring to sheet floor construction and slab-on-ground floors. Another change at a similar time was the shift from timber joinery to aluminium-framed doors and windows. Newer construction practices have continued to influence the airtightness of houses. Relatively recent examples of changes are the widespread use of bonded plaster cornices or a square stopped interior plaster finish, the adoption of air seals around window and door assemblies to control rain penetration and the increased use of rigid sheathing.

Regulations in New Zealand and overseas

There is no direct requirement to meet a particular level of airtightness in the Building Code. Airtightness is mentioned indirectly in clause H1 *Energy efficiency*, which states that

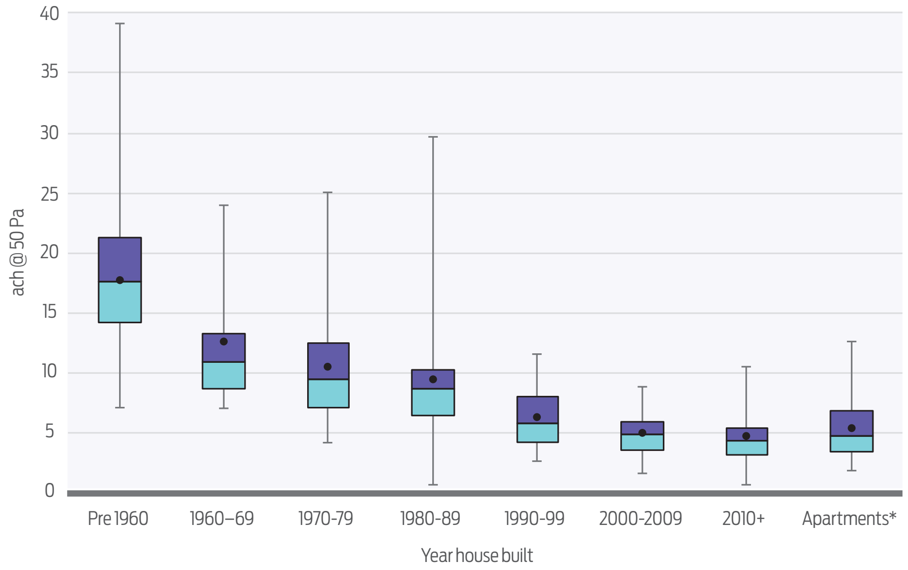

Figure 1. Comparison of observed airtightness in apartments with New Zealand houses over time. The black dots show average value, and the blue and purple bars show the 25th to 50th percentile and 50th to 75th percentile respectively.

buildings must achieve an adequate degree of energy efficiency by limiting uncontrollable airflow and taking the airtightness of the building envelope into account (along with other requirements).

BRANZ investigated overseas airtightness requirements and recommendations from overseas (for details, see Table 1 of Study Report SR455). Even though New Zealand does not have a direct requirement, the typical airtightness in a new-build house or apartment is already close to targets in other countries.

However, overseas requirements span a large range of required airtightness targets. Many of these requirements are linked with energy rating schemes, with a higher energy rating in a building being an inducement to build more airtight. Also, some countries have different requirements depending on whether the buildings are naturally ventilated (typically 3-5 ach @ 50 Pa) or mechanically ventilated (typically 1-3 ach @ 50 Pa). Testing to validate the airtightness is not always mandatory.

Underventilation in New Zealand dwellings

New Zealand houses have generally relied on infiltration to supplement deliberate ventilation (opening windows or using extractor fans), which may not provide adequate ventilation overall. As airtightness in houses has improved over time, more newer houses are likely be underventilated. This was previously observed by BRANZ in a study of ventilation rates in occupied dwellings using passive tracer gas techniques.

BRANZ subsequently investigated the infiltration at various levels of airtightness at a test house in Porirua and the results were used to calibrate computer models of the infiltration rate for typical weather conditions over a year.

This model was used to calculate the infiltration rate for a single-storey house in Christchurch (Figure 2). At an airtightness of 9 ach @ 50 Pa, the average infiltration at the house is close to the required ventilation requirements shown in green but the ventialtion is not well-controlled and it varies.

At an airtightness of 5 ach @ 50 Pa (typical for a new Code-compliant dwelling in New Zealand), the infiltration rate is consistently below ventilation requirements and the houses would be reliant on actively ventilating the space.

Achieving adequate ventilation in newer dwellings therefore relies on the occupants managing the ventilation (opening windows regularly and using spot-exhaust systems appropriately) or installing mechanical ventilation systems.

Forcing buildings to be more airtight without addressing ventilation at the same time could increase the proportion of underventilated buildings. Any initiative to set a target for airtightness in residential buildings should also therefore include more comprehensive ventilation requirements than are presently in the Building Code.

At an airtightness of 3 ach @ 50 Pa there is less variation (Figure 2), meaning mechanical ventilation can be installed to give sufficient and consistent ventilation.

Airtightness, ventilation and heat recovery

Any recommendation about a target for airtightness should also consider energy efficiency, as heat losses are associated with infiltration and ventilation, as mentioned by the requirements in Building Code clause H1 Energy efficiency.

An ideal ventilation scenario for a dwelling would be one where infiltration is minimised, the ventilation is controlled and the heat loss associated with any airflow is minimised. This sort of building has minimal infiltration and whole-house mechanical ventilation systems so that the ventilation is controlled. The systems include heat recovery so that the outgoing air does not carry useful heat away.

Typical New Zealand dwellings are ventilated differently. In a Code-compliant house in New Zealand (expected airtightness around 5 ach @ 50 Pa), there would be considerably more infiltration than the ideal ventilation scenario, depending on wind pressures, the locations of air leakage points and the temperature difference between inside and outside. There is also normally no attempt to recover heat from outgoing air.

BRANZ modelled the approximate heat losses for a similar single-storey house in Christchurch (Figure 3) at two airtightness levels - 3 ach @ 50 Pa and 5 ach @ 50 Pa - with mechanical ventilation at 0.4 ach (more straightforward to model), both with and without heat recovery (70% overall efficiency, with ducting assumed to be within the thermal envelope). Two levels of insulation were considered: the method included in NZS 4218:2009 *Thermal insulation - Housing and small buildings* and the Homestar V4 schedule method for 7 Homestar, which has insulation higher than the minimum Code requirements.

Figure 3 shows that, given the airtightness typically associated with new houses built today, the argument for introducing airtightness targets based on energy savings alone is

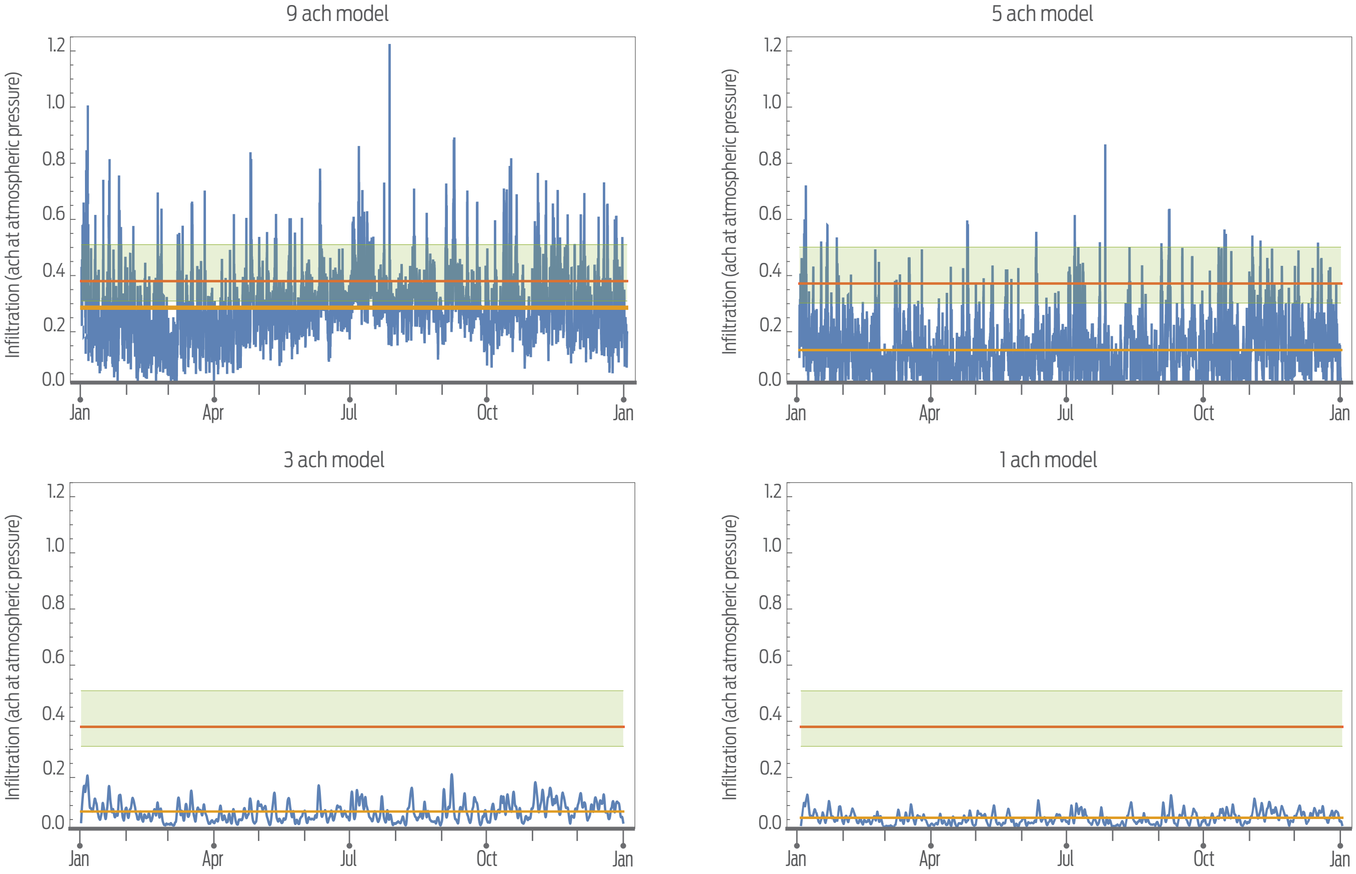

Figure 2. Estimated infiltration rates for different levels of airtightness for a house in Christchurch, based on measurement at a BRANZ test house. Green shading indicates infiltration at the house is close to the required ventilation requirements

not that strong in New Zealand. The overall drop in energy loss between buildings at 5 and 3 ach @ 50 Pa, when built to NZS 4218 and without a heat recovery system, is not a significant percentage of the total heat loss of the building.

As the effectiveness of the insulation in walls, ceilings and windows increases, the overall heat loss decreases significantly. For the house built to 7 Homestar (Figure 3), infiltration and ventilation heat losses become more significant relative to the total heat loss, so investing in heat recovery may be more effective. At the same time, airtightness control becomes more important so that the investment in the insulation and heat recovery system is not undermined.

If upgrades to the Building Code or voluntary standards are made, it would be logical to do this holistically and increase required insulation at the same time as introducing airtightness requirements and requirements for controlled ventilation. If mechanical ventilation is introduced, the energy losses from ventilation are more predictable and can be factored into the design.

Discussion

It is clear from other countries that airtight buildings are achievable, but this is likely after continued regulatory effort on airtightness over some time. In New Zealand, any target for airtightness would represent a step change from the status quo.

Specifying an optional airtightness target represents a possible transition to airtightness being commonly measured in new dwellings

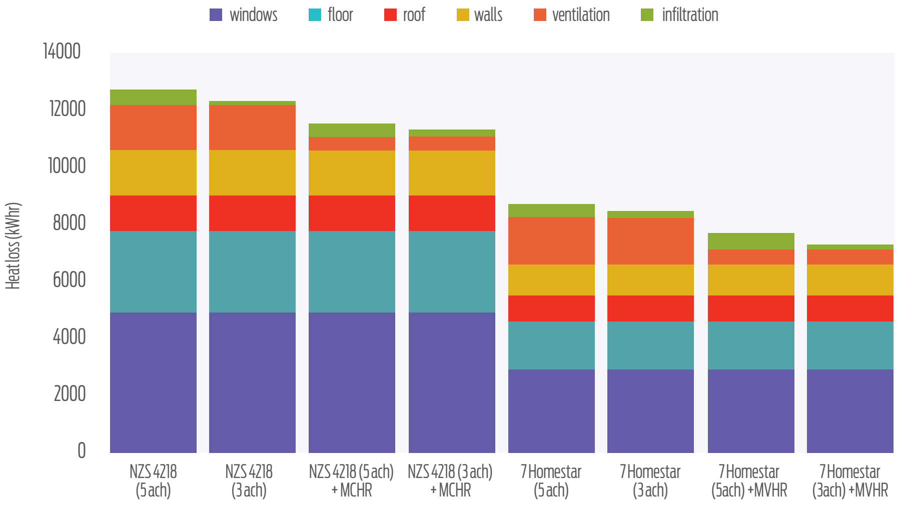

Figure 3. Sources of heat loss estimated for a single-storey house in Christchurch estimated using the BRANZ Annual Loss factor (ALF) tool. Scenarios with heat recovery systems are labelled MVHR.

in New Zealand. Given the typical airtightness already observed by BRANZ in new residential stock, a practical approach may be to introduce new Acceptable Solutions to help seal the most prevalent leakage pathways (bottom plates, pipe penetrations) along with an optional 3 ach @ 50 Pa target for a measured building airtightness. This should be an achievable target for industry with minimal additional cost. A set of easy-to-inspect details to reduce leakage where it is most prevalent would tighten the distribution of measured leakage in new stock.

If the Building Code or voluntary standards are revised, it would make sense to consider airtightness control, ventilation, heat loss and energy efficiency together. Installing mechanical ventilation systems as standard would ensure there is adequate ventilation at this level of airtightness. For houses where the airtightness is 3 ach @ 50 pa or less, the infiltration level is low (Figure 2), giving a good base for mechanical ventilation.

Heat losses from ventilation can be reduced using a heat-recovery system, but the cost benefit of installing systems should be considered relative to savings that can be made elsewhere. For houses around or moderately above Building Code levels of insulation, the reduction in infiltration from 3 to 1 ach @ 50 Pa is not that significant for ventilation heat loss.

Improving airtightness by addressing known major pathways for air leakage would reduce the need for an immediate testing regime, easing the regulatory impact. However over time, BRANZ recommends a transition to airtightness testing as the norm, as the only way to find out if this target has been met in a new build is to test the construction.

BRANZ thanks all involved in allowing access to test in their buildings. This research was funded by the Building Levy.

Major pathways for leakage Identified by previous BRANZ research

- Bottom plate/floor/plasterboard junctions.
- Window and door edge sealing details.
- Plumbing penetrations.
- Electrical penetrations.
- Lack of detailing behind bathtubs and fireplaces.
- Downlights/ceiling penetrations.

More information

Study Report SR455 *Airtightness of selected apartments in New Zealand*

Study Report SR341 *The role of ventilation in managing moisture inside New Zealand homes*

Research Now: Indoor air quality #3 *The impact of ventilation in New Zealand houses*

Research Now: Warmer drier healthier #4 *Airtightness in apartments in New Zealand*

BRANZ Annual Loss factor (ALF) tool http://alf.branz.co.nz/