Rapid Review – Summary

What impacts does increasing airtightness have on mould, condensation and measures of indoor air quality?

Objectives of this Rapid Review

Leaky homes need more energy to keep warm or cool. Sealing the gaps in a house, or increasing airtightness, is a common tip to reduce energy consumption, as well as make the house more comfortable to live in. However, people need a certain amount of fresh air in their homes to maintain air quality, and concerns have been raised that increased airtightness may have the unintended consequence of reduced indoor air quality (IAQ).

Airtightness is only part of the story though. Fixing air leaks in a building will reduce the air movement through cracks and gaps, known as infiltration. However, there are other sources of fresh air in a building. If designed appropriately, natural ventilation (which is air exchange through doors and windows) and mechanical ventilation (such as exhaust fans or ducted ventilation systems) can ensure minimum fresh air levels are maintained in a building regardless of airtightness. This is captured in the maxim “seal tight and ventilate right”. Most building regulations require mechanical ventilation to be installed once airtightness goes beyond a certain level.

Increased stringency in airtightness requirements has been foreshadowed as a possible inclusion in future versions of the National Construction Code (NCC)[1,2] so it is important to understand what, if any, unintended consequences there might be. Our review explored the recent literature to answer the question “What impacts does increasing airtightness have on mould, condensation and measures of indoor air quality?”

Airtightness is measured using blower door testing.

IAQ is a catch-all term to indicate the potential health risk in a building from a range of pollutants. These pollutants can come from items within the home (for instance, new paint is a major source of volatile organic compounds (VOCs) in a home) or from outdoor air entering the home (for example, small particulates from motor vehicles or bushfire smoke events). Mould has also been identified as a possible risk, as there is the potential for increased condensation if water vapour control is not adequately considered.

Key findings of this rapid review

The main finding of this review was that if the pollutant is from an external source, airtightness is likely to be good for IAQ, whereas if the pollutant is from an internal source, airtightness will likely worsen IAQ.

For locations with high levels of particulate matter ($PM_{2.5}$) or nitrogen dioxide (NO_2), in the outside air, a relatively clear trend was identified that tighter buildings resulted in lower pollutant concentrations. Conversely, levels of VOC and carbon dioxide (CO_2) were higher in more airtight buildings, as these pollutants are generated indoors, and have less ability to escape from an airtight building. However, further research is still needed to better understand this relationship.

This review also highlighted that the issue of mould and mould risk is complex. Nine studies reported on mould, or mould related risk factors (e.g. relative humidity). Three studies used direct mould observation, and two of these found that increased airtightness actually reduced the occurrence of mould. This goes against commonly held views that increasing airtightness may increase mould risk. The study authors put this down to leaky homes having more issues with water leakage, though it could be an indication of confounding variables. Two of the four studies that measured relative humidity found an increase which can increase the risk of mould in airtight homes. The remaining two studies found no relationship). The two

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1 ASBEC (2018), ‘Built to Perform An industry led pathway to a zero carbon ready building code’, Australian Sustainable Built Environment Council, Building Code Energy Performance Trajectory Project - Final Report July 2018

2 ABCB (2020), ‘NCC 2022 Residential Energy Efficiency. Frequently asked questions’, Australian Building Codes Board, p. 3, Q 13, accessed at https://www.abcb.gov.au/-/media/Files/Resources/Education-Training/FAQ_NCC2022_Residential_Energy_Efficiency.pdf.

simulation studies also showed a similar increased risk of mould growth for more airtight homes.

Methods, limitations and future research

In total, 21 studies were included in this review. These studies were published between 1998 and 2019, and covered 10 countries, with most studies coming from the United Kingdom (7) or North America (6). The studies cover a variety of climates, although the largest number of studies were in temperate climates similar to the cooler temperate climate of south-eastern Australia.

The reviewed studies took place in a mix of existing buildings, buildings being upgraded and new builds. Detached houses, apartments and semi-detached properties were covered. To work out how airtight a building was, most studies used a blower door test. There was a range of tightness levels, from very airtight to very leaky, but most studies were focussed on more airtight properties.

The review had a number of important limitations. An important question that could not be answered by this current review was what impact the occupant of the homes in these studies has on IAQ through their ventilation practices. Advocates of airtight homes suggest appropriate ventilation will mitigate any increased risk of mould or pollutants. However this necessitates either mechanical ventilation (which is not currently common in Australian homes) or engaged and educated occupants.

Another limitation in the studies was sample size. Most of the studies had a sample size of less than 25 homes, which makes it hard to draw general conclusions. The length of time each home was monitored also varied, meaning some studies took place in both winter and summer, while others did not, and short-term changes in outdoor pollutant levels may have been important. This means the comparisons are in some cases less valid.

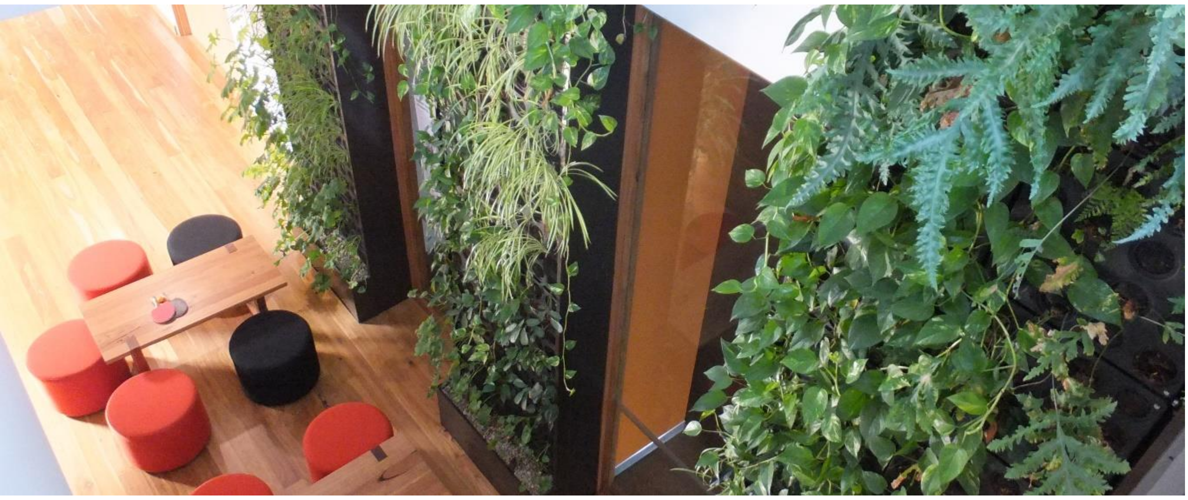
Three important pieces of future work would be:

- To consider airtightness in the context of total ventilation rates for a home. This is particularly important for understanding mould risk, which appears to have a complex relationship with airtightness.
- Research focused on the threshold at which mechanical ventilation is typically implemented (usually 5 air changes per hour at 50Pa - ACH_{50})
- Larger and more long-term studies are still required to improved confidence in this area.

Summary and conclusions

This rapid review identified 21 studies that investigated the impact of increasing airtightness on indoor air quality. These studies covered a broad range of locations, climates and building types. Indoor air quality parameters investigated were CO_2, $PM_{2.5}$, formaldehyde, VOC, NO_2, relative humidity, mould issues, carbon monoxide (CO) and radon.

Based on the studies reviewed, there was limited evidence to identify direct correlations between increasing airtightness and indoor air quality in general. A negative correlation with CO_2 and VOC concentration was found from the studies, with concentrations increasing with a decrease in the air exchange rate. A positive correlation was found between the air exchange rate and $PM_{2.5}$ and NO_2 concentrations in areas where there were high outdoor levels. In these cases, increasing airtightness was found to reduce the infiltration of outdoor contaminants. There were no direct correlations identified for mould issues, formaldehyde, radon or CO, or for $PM_{2.5}$ or NO_2 in areas with average outdoor levels.



Green walls are designed to improve indoor air quality

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Full Report

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