Optimal ventilation?

Conventional ventilation keeps a home sufficiently aired but has an energy cost. An option is to install a mechanical ventilation heat recovery system that ventilates a home while efficiently conserving energy.

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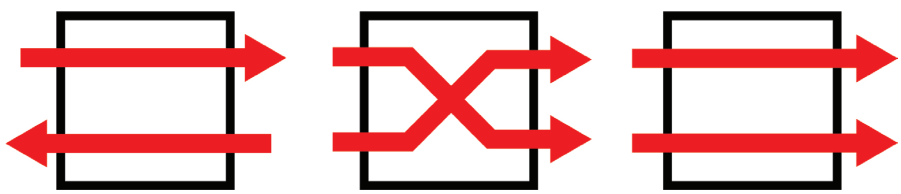
IN NEW ZEALAND HOMES, New Zealand Building Code clause G4 *Ventilation* specifies that adequate ventilation is required to be provided through a combination of natural means - with windows and openings - and mechanical ventilation. The most common pathway for compliance with G4 is natural ventilation, with supplementary extract ventilation in bathrooms, for example.

Opening windows does the job

In a BRANZ study (see *Build* 158, *Open windows for dry homes*), we showed ventilating by opening windows and doors provides sufficient ventilation to manage moisture in the building.

Small window openings can take an hour or more to vent excess moisture, but opening the windows wider removed a significant portion of excess moisture within 15 minutes. However, anecdotally, we have found there is a reluctance to open windows due to the perception of too much heat being lost through outgoing air.

If we calcuate heat lost from ventilating using windows, the electricity cost for a flush ventilation of a fully heated house of 100 m² with an indoor-outdoor temperature difference of 10°C is found to be around 1 kWh per flush.



(a) Counter-flow heat exchanger – theoretical heat transfer 100%.

(b) Cross-flow heat exchanger – typical heat transfer 70%.

(c) Co-flow heat exchanger – theoretical heat transfer 50%.

Figure 1: The three basic heat exchanger core designs.

Mechanical ventilation and heat recovery

The desire and, in some countries, the requirement to conserve energy has resulted in ventilation systems that recover heat from the outgoing ventilated air and use it to heat up the colder outside air brought in to replace it.

These mechanical ventilation heat recovery (MVHR) systems can be broken down into three basic heat exchanger core designs - co-flow, cross-flow and counter-flow heat exchangers. The co-flow and counter-flow designs have maximum efficiencies of 50% and 100% respectively and the cross-flow design have an efficiency range between 65% and 75% (see Figure 1).

Case study in a 100 m² house

A residential MVHR unit retrofitted in the ceiling space of a 100 m² house was equipped with sensors to measure the performance in situ. Decisions on the layout and installation of the unit were left to the installer to achieve a similar standard of product typically retrofitted in residential homes.

AS 1668.2-2012 *The use of ventilation and airconditioning in buildings - Part 2: Mechanical ventilation in buildings* specifies a house should be ventilated at 0.35 air changes per hour. This means, after approximately 3 hours, all the air in a house would have been replaced.

The MVHR system in the house was set to conform to this standard, and all rooms were heated to the WHO recommendation of a constant 18°C.

Efficiency and airflow balance

Core air temperatures were measured to calculate the efficiency of the MVHR core and found to be around 90%. For a cross-flow core, this is much higher than expected.

In reality, heat recovery efficiency depends on the balance of airflow through the core. An imbalance between the supply/return air flows skews the achieved efficiency if the core temperatures only, and not the airflows, are taken into account.

After measuring the true airflow, the return airflow was found to be greater - that is, the system was unbalanced. The actual heat recovery efficiency of the MVHR core was around 70%, in line with expectations. If the make-up air losses from an imbalanced system are accounted for, the system efficiency becomes highly dependent on the flow balance (see Figure 2).

Optimise ducting length and insulation

Typically, a retrofitted MVHR system is installed in the ceiling space or subfloor as these areas provide easy access to install equipment. This can pose an issue, however, as warm air must travel through space outside the thermal envelope of a building.

Duct walls are a significant path for heat loss with MVHR systems. Often readily available, easy to install flexible ducting is offered, which usually has a very low insulation R-value of 0.8 or 1.

The MVHR system we measured used flexible ducting with a combined length of about 25 m. When assessing the performance of the whole system - ducting and core - the efficiency decreased from the ideal 70% of the MVHR core alone to around 40% for the ventilation system as a whole.

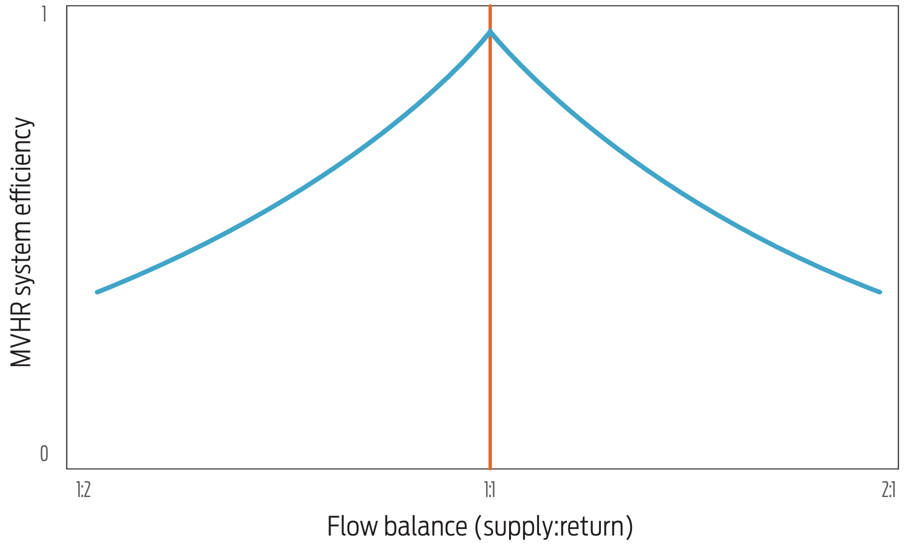


Figure 2: Relative MVHR system efficiency with ventilation losses depending on the supply/return flow balance shown here between the flow ratios of 1:2 to 2:1.

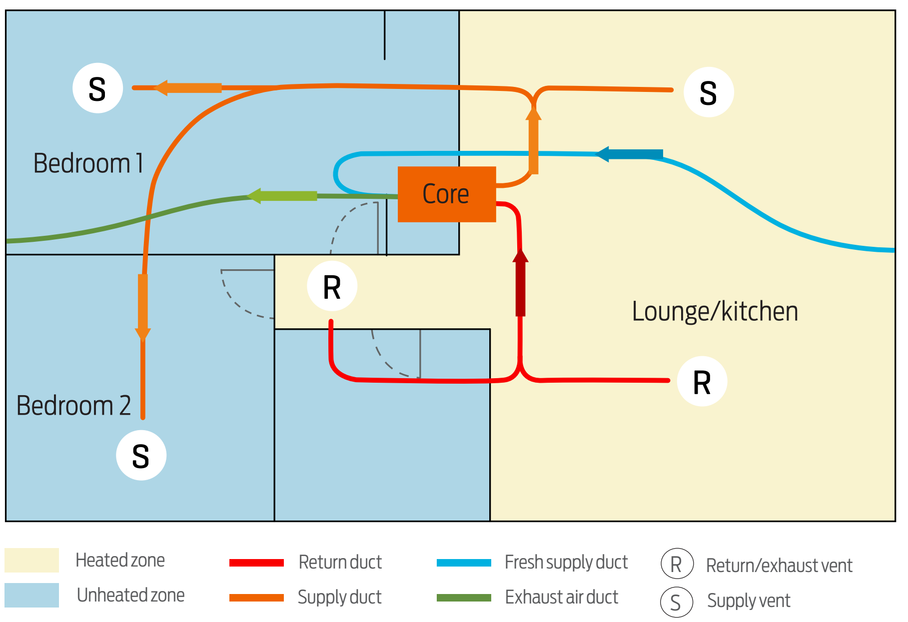


Figure 3: Spot heating means the house can be treated as two zones.

In optimising the ducting length, we shortened it by about 10 m. An extra layer of R1.5 blanket was also added around the ducting bringing it to about R2.4 - increasing the system performance to almost 60% efficiency.

This simple measure improved the performance of the whole system by about 50%.

Homes often spot heated

MVHR systems are designed so that each room connected to the system is heated to a similar temperature. Research shows this is rarely the case in New Zealand homes.

Spot heating is often encountered where only one room - typically the lounge or family room - is heated at certain times of the day.

Spot heating means the house can be treated as two zones, one heated and one unheated, but both share the MVHR system.

Spot heating causes efficiency to drop

To understand how an MVHR system performs in these conditions, we modelled an MVHR system using temperature data measured in 16 homes in Lower Hutt, Wellington. The model has two zones, a heated and an unheated one. Both zones have return and supply diffusers providing 0.35 ach (see Figure 3).

The cold return air from the unheated zone with the supply air shared between heated and unheated zones caused a drop in efficiency. This arrangement slightly heats the unheated room and acts like a heat transfer system, which might not be the desired outcome.

There are two options - the system could be shut down or the diffusers for the unheated space could be closed. Drawbacks would be the loss of ventilation or the over-ventilation of the heated area if the unheated zone diffusers were just closed without altering the flow rate.

Getting the highest efficiency

To achieve optimal heat recovery with an MVHR system with typical usage patterns, consider these points:

- Is an MVHR system appropriate for the building compared to other mechanical ventilation options? Improvements that are easier to achieve such as using better glazing to reduce heat loss through the thermal envelope would be a better investment than looking at MVHR. In addition, the airtightness of the building should aim to be less than 3 air changes per hour at 50 pascals to achieve optimal benefits from an MVHR unit. Most houses built post-2005 could be remediated with little extra effort to achieve this airtightness level (see *Build* 166, *Airtightness trends* Figure 1).
- The warm air side ducting paths should be installed within the thermal envelope. If they can't be, the total ducting length should be short and well insulated.
- The whole house should be heated. If the whole house cannot be kept heated, the MVHR system will operate less efficiently and a demand-controlled system might be worthwhile investigating.
- The cold side ducting should be installed outside the thermal envelope and the fresh air intake should be insulated to minimise overheating from solar gains during warmer months.