SOLUTIONS FOR MVHR IN EXISTING DWELLINGS

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ABSTRACT

For retrofitting of existing dwellings MVHR is seldom applied, despite the potential in energy saving and improving thermal comfort and indoor air quality. Major barriers and limitations for application are lack of space, especially for the supply ducts and the MVHR units as well as the complexity of execution. Also initial costs are an important barrier. Limiting supply ducts could be beneficial for application in single family dwellings. In a study some configurations with simplified air supply with MVHR in single family dwellings have been investigated. The main principle is supplying air only on the first floor and internal air transport by overflow provisions to the exhaust points.
Simulations with COMIS show the CO_2 levels in habitable rooms for different configurations and the Low Ventilation Index (Lvi) in relation to a reference situation with natural supply and mechanical exhaust. Good quality overflow provisions are crucial in this concept. Simulation show a Lvi < 0.005 which is equal (and in some cases even better) then the reference situation. In a number of field experiments ventilation efficiency of different configurations have been measured with tracer gas.
In collaboration with the company Agpo BV some industrialised prefab solutions for simplified air supply have been developed and tested in retrofitted dwellings.

KEYWORDS

Mechanical ventilation with heat recovery, retrofitting, dwellings, ventilation efficiency

INTRODUCTION

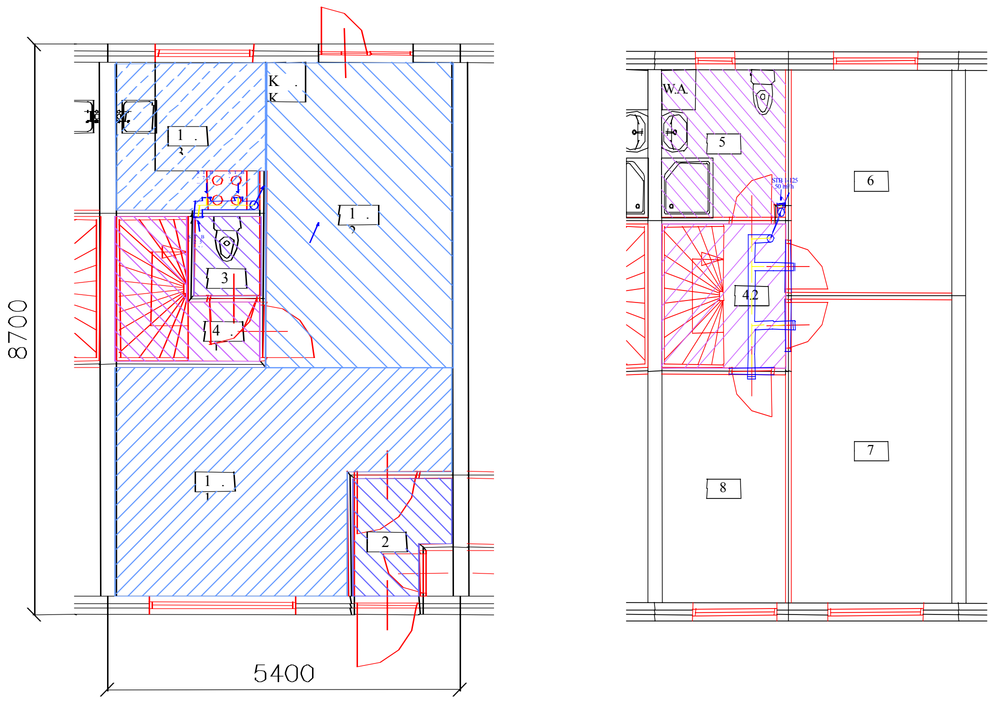
Since the introduction of the Energy Performance Regulations in the Netherlands in 1996 the market share of mechanical ventilation with heat recovery (MVHR) increased from 0.5% in 1995 to 50% in 2003 in new dwellings. The main driving force in the market is the building regulations, especially the Energy Performance Regulations, introduced in 1996 and sharpened in 1998 and 2002. In 2006 the allowable energy consumption will be sharpened to half of the level of 1996. The Dutch Energy performance regulations are only mandatory for new buildings. For retrofitting of existing dwellings MVHR is seldom applied, despite the potential in energy saving and improving thermal comfort and indoor air quality. Apart from the lack of standards and regulations as a driving force also other barriers occur. Major barriers and limitations for application of MVHR in existing dwellings are lack of space, especially for the supply ducts and the MVHR units as well as the complexity of execution. Also initial costs are an important barrier. Limiting supply ducts could be beneficial for application in (common) single family dwellings.
Therefor the feasibility of a simplified supply ductwork is investigated for single family dwellings. The main principle for this simplified ductwork is supply of air only on the first floor (bedrooms and landing). Exhaust of air takes place in kitchen and toilet (ground floor) and bathroom (first floor). The idea is that the supplied air on the first floor will flow from bedrooms and landing through internal overflow provisions to the exhaust points on the ground floor. There are 4.2 million single-family dwellings in the Netherlands; about 2.2 million single-family dwellings have a lay out of the ground floor with a so-called open kitchen, i.e. a kitchen adjacent to the living room. For these dwelling types there are no restrictions. The air will flow from the first floor through the living room to the exhaust points

in the kitchen. These dwellings will need a certain level of air tightness to avoid cross flow ventilation.
The Dutch building regulations state that the supply of air to habitable rooms must come for at least 50% directly from outside. In other words, the proposed solution does not comply with the building regulations. However, using the Principle of Equivalence, it is allowed to apply this solution if it is proved that this solution gives an equal performance (in terms of indoor air quality).
This equal performance is assessed as follows:

- by simulating the air flows and indoor air quality, assessing the Low Ventilation Index (Lvi);
- by ventilation efficiency measurements.

SIMULATIONS

Simulations have been carried out with the multizone ventilation modelling programme COMIS. For the simulations a typically Dutch standard reference building was used, see figure 1.



ground floor first floor

Figure 1 Dutch Reference dwelling used for simulations

Three situations have been modelled:

1. traditional ventilation system:
   - natural supply by ventilation provisions in facade;
   - mechanical exhaust in kitchen, toilet and bathroom;
   - internal airflow to living room/kitchen by overflow provision in door to living room.

2. simplified MVHR
   - mechanical supply in bedrooms and landing (42 – 63 dm^3/s);
   - mechanical exhaust in kitchen, toilet and bathroom;
   - internal airflow to living room/kitchen by overflow provision in door to living room.

3. simplified MVHR with improved overflow
   - mechanical supply in bedrooms and landing (42 – 63 dm^3/s);
   - mechanical exhaust in kitchen, toilet and bathroom;
   - internal airflow to living room/kitchen by improved overflow provisions in door to living room an extra overflow grille in wall (between zone 4.1 and 1.1, see figure 1).

All modelled situations have same boundary conditions for occupancy patterns and behaviour, use of airing provisions and the mechanical ventilation. CO_2 production is calculated by COMIS. The performances of the three situations are assessed by the Low Ventilation Index. The Low Ventilation Index is determined as follows:

1. calculation of the effective ventilation by
   $q_{en} = C_{target}/C_t$

   q_{en} = effective ventilation; ($q_{en} \leq 1.0$)
   C_{target} = target concentration ppm ($C_{CO2} > 1200$ ppm)
   C_t = occurring concentration in ppm

   For example: for dwellings target concentration CO_2 = 1200 ppm

2. plotting a histogram of the effective ventilation during the simulated period

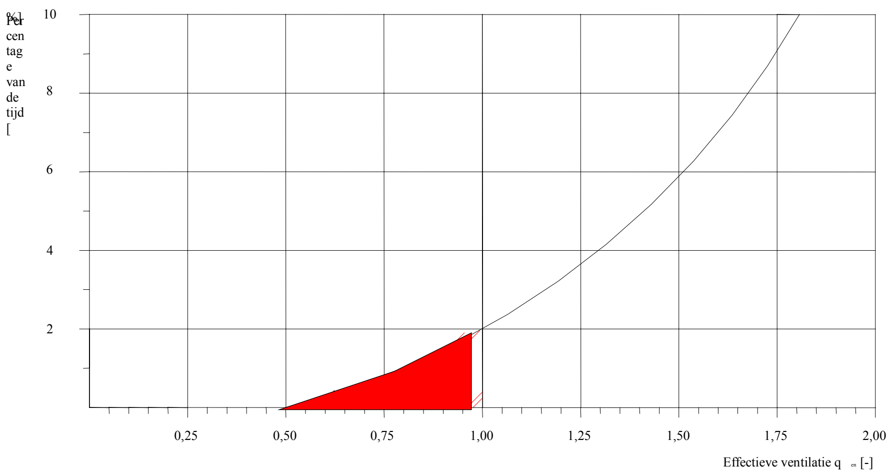


Figure 2 Example of histogram for determining the Low Ventilation Index

The Lvi is the marked part of the histogram for $q_{en} < 1$ and the corresponding time interval.

For dwellings (in the Netherlands) the maximum value of Lvi is 0.005 (-)

In table 1 a comparison is given of the Lvi values for the 3 situations in the living room.

Table 1. Lvi living room for 3 situations

Case	**Lvi**
1 traditional system (natural supply, mechanical exhaust)	0.1054
2 simplified MVHR supply 1st floor	0.1437
3 simplified MVHR supply 1st floor with improved overflow	0

For the traditional system a peak concentration of CO_2 in the living room of 4200 ppm occurs between 20.30 and 21.00 h (all occupants in living room). For case 2 the peak value is even 8700 ppm between 22.00 and 22.15 h. For case 3, simplified MVHR with supply on the 1st floor and improved over flow to the living room, the maximum CO_2 concentration of 1200 ppm is not exceeded. In figure 3 the time related CO_2 concentrations for this situation is given for all rooms for a number of classes of CO_2 concentrations.

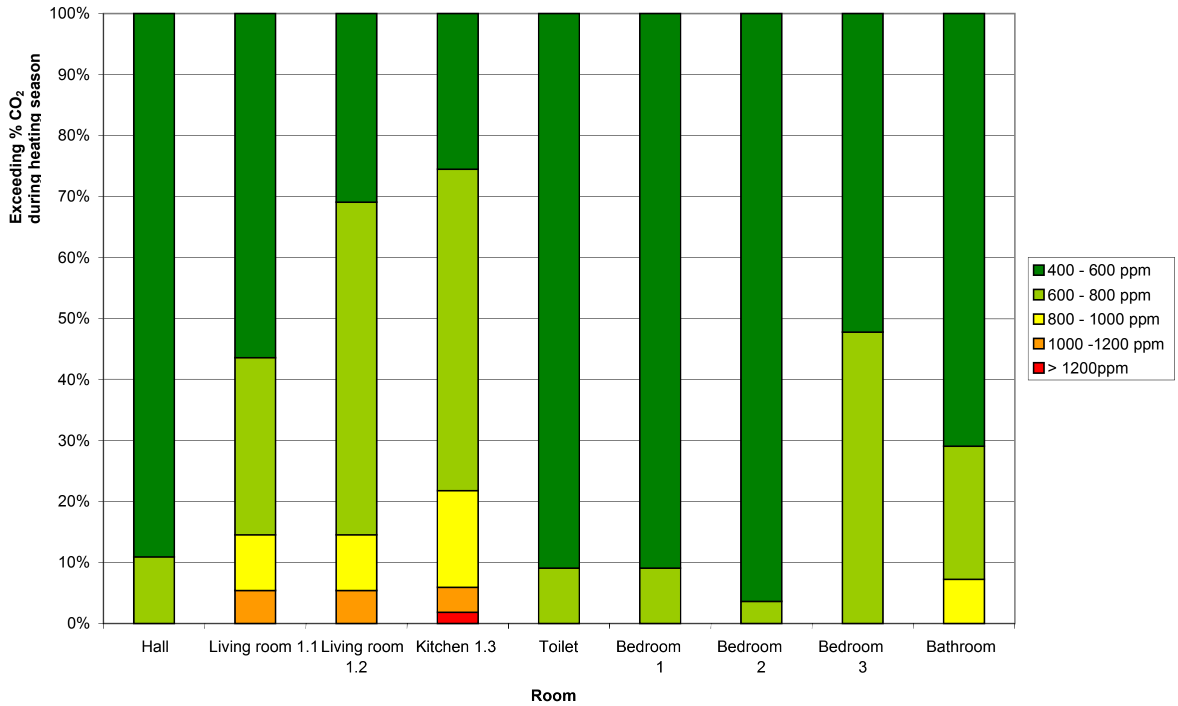


Figure 3 Time related CO_2 concentrations for MVHR with simplified supply and improved overflow

In the kitchen the target concentration of 1200 ppm is exceeded for 2% of the time. This is due to the fact that the exhaust point in the kitchen is the “end-point” of the total air flow path in this dwelling. However, the maximum CO_2 concentration in the kitchen occurs at 19.00h. At that time there are no persons present in the kitchen.

VENTILATION EFFICIENCY MEASUREMENTS

The feasibility of a MVHR system with simplified supply was also tested in a single family dwelling (with open kitchen) by measuring and comparing the ventilation efficiency and local air change rates in the living room for following situations:

- a reference situation with mechanical supply in the living room;
- situation with simplified supply on the first floor and overflow provisions.

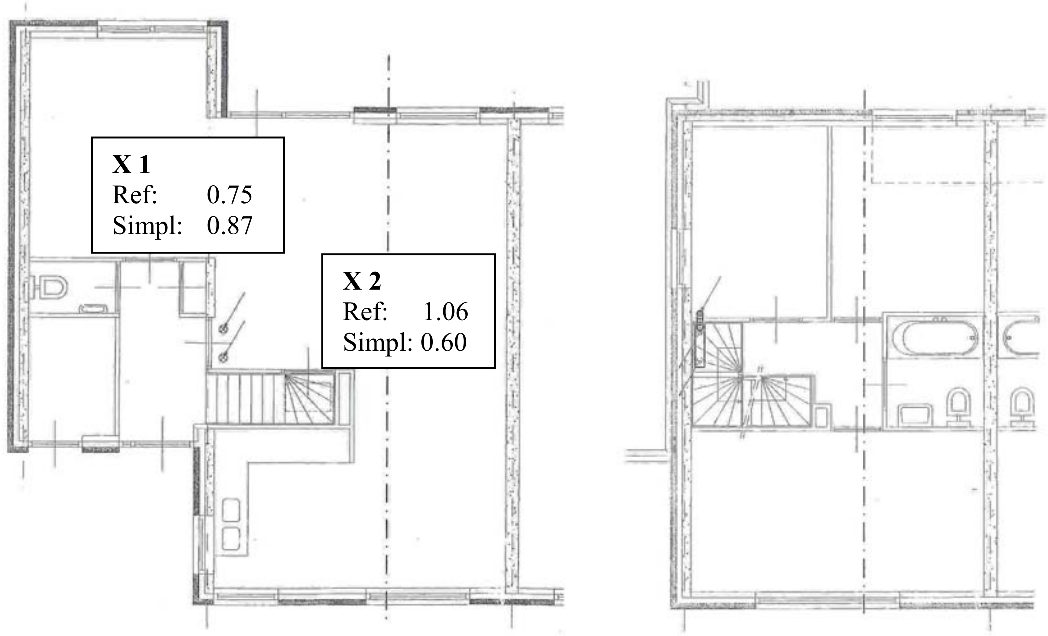


Figure 4 Measured dwelling in situ

The measured local air change rates are given in table 2

Table 2. Measured local air change rates in situ

Position	Reference supply in living room	Simplified supply 1st floor
1	0,75	0,87
2	1,06	0,60
average	0.91	0.74

Position 1 is a measuring point situated in a “dead corner” of the living room, but near to a door with an overflow provision. Position 2 is situated in the middle of the room near two supply grilles (in the reference situation). For position 1 the local air changes rate increases while for position 2 it decreases. However, for both situations and both positions the local air change rates satisfy the minimum rates conform the building regulations. Again, as in the simulations, the position of the overflow provision(s) is very important. No tests have been performed with an improved overflow for position 2 but it can be expected that this will increase the ventilation efficiency on this point.

INDUSTRIALISED SOLUTIONS FOR SUPPLY AIR

One of the problems with application of MVHR in existing dwellings is design and mounting of the ductwork (supply and exhaust). In many cases only natural ventilation with passive stacks is present. This means that for the application of MVHR supply ducts as well as exhaust ducts have to be installed. Often the dwelling lay out is such that supply and exhaust ducts have to cross. This can be a problem when the ceiling height is limited.
In collaboration with Agpo BV, the Netherlands, some industrialised solutions for the simplified supply ducts have been developed. These solutions are based on a prefabricated plenum for the supply air (height 150 mm) that fits to the ceiling of the first floor landing. From this plenum connections can be made to the bedrooms. The plenum has also extra grille supplying the landing. With the fan in high position 50% of the air is supplied to the bedrooms and 50% to the landing. During the nighttime the fan runs at 50% of its capacity with 100% supply to the bedrooms. This has the advantage of supplying the full amount of air to the bedrooms without needing the fan switched in the high position (less noise). In case the grilles to the bedrooms are closed all air is supplied to the landing. If necessary exhaust ducts can be placed within the plenum thus avoiding crossings with supply ducts.

CONCLUSIONS

Both multizone ventilation simulations as well as measurements in situ show that a good ventilation and indoor air quality can be achieved by applying MVHR with a simplified supply system, supplying air only on the first floor. This application has following boundary condition:

- lay out of the ground floor must be suitable, i.e. there must be a logical air flow path from the staircase via the living room to the exhaust points in the kitchen;
- position and dimensions of overflow positions are critical;
- air tightness must be good ($n50 < 3$).

Advantages of this simplified supply system are:

- very short and limited supply duct systems or even no supply ducts when applying the prefabricated supply plenum;
- very limited pressure losses;
- low noise levels due to the low pressure losses and due to the fact that during night time the fan can run at lower speed but still providing the bedrooms with the nominal air flows.

Disadvantages of this simplified supply system is

- only applicable (without major limitations) in single family dwellings with open kitchen (approximately 50% of the Dutch single family dwellings);
- for single family dwellings with closed kitchens additional overflow provisions are necessary.

REEFERENCES

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