EUROVENT
EUROPEAN INDUSTRY ASSOCIATION

EUROVENT GUIDEBOOK

RESIDENTIAL HEAT RECOVERY VENTILATION UNITS

SEPTEMBER 2021 | FIRST EDITION


©Alnor Sp. z o.o.

PREFACE

This Guidebook provides a comprehensive overview of residential heat recovery ventilation, regarding design, construction, and operation. In most cases, heat recovery ventilation is the best air exchange solution in moderate and cold climates. The Guidebook is primarily targeted at installers and planners but also contains important information for end users. It combines fundamental principles of engineering with practical hints based on the expertise of Eurovent members. The first two parts are focused on system design and sizing. The third part regards residential ventilation units, which are at the heart of the system. It discusses their essential functions, features, and performance indicators, which should be considered at the design stage. The last chapter addresses system commissioning and operation.

AUTHORS

This document was published by Eurovent and was prepared in a joint effort by participants of the Product Group 'Residential Air Handling Units' (PG-RAHU), which represents a vast majority of all manufacturers of these products active on the EMEA market. This Guidebook was prepared in cooperation with REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations).

Particularly important contributions have been provided (in alphabetical order of the last name) by Jan Andersson, Vytautas Astrauskas, Xavier Boulanger, Jaroslav Chlup, Wolfgang Grassler, Henning Gronbaek, Artur Kolacz, Jarek Kurnitski, Gabriel Rojas, Igor Sikonczyk, Emmanuel Val.

COPYRIGHT

SUGGESTED CITATION

Eurovent AISBL / IVZW / INPA. (2021). Eurovent Guidebook – Residential Heat Recovery Ventilation Units. Brussels: Eurovent.

CONTENTS

PART 1:
FUNDAMENTALS FOR THE DESIGN AND INSTALLATION OF RESIDENTIAL VENTILATION SYSTEMS WITH HEAT RECOVERY

1. WHY VENTILATE? WHY MECHANICAL BALANCED VENTILATION? WHY HEAT RECOVERY?

1.1 WHY VENTILATE?

Clean air is of fundamental importance to human health and wellbeing. It is especially important to ensure the supply of clean air in buildings, because people spend around 90% of their time indoors, including at home. Effective ventilation is also very important to preserve the condition of the building itself, by preventing physical damage to its structure or mould outbreaks linked to excess moisture.

The role of ventilation is to replace indoor air with fresh outdoor air in order to fulfil one or more of the following objectives:

a) Dilution and elimination of natural pollutants such as substances emitted by furniture, building materials, cleaning products, as well as odours, metabolic CO_2 and water vapour
b) Dilution and elimination of specific pollutants from identifiable local sources such as toilet odours, kitchen odours, kitchen or toilet water vapour, environmental tobacco smoke, combustion products from fuel appliances
c) Provision of fresh air for breathing
d) Control of indoor humidity
e) Supply of air for fuel appliances

These goals are all related to the health of building occupants. Usually, the first four objectives (a) to (d) are of primary importance, but in some cases, ventilation also serves the last function (e).

1.1.1 Pollution of indoor air

A large number of airborne pollutants, including gases, vapours, tobacco smoke, biologically inert particles (e.g. dust and fibres) and viable particles (e.g. fungal spores, viruses and bacteria) are generated by sources inside the dwelling. These pollutants are known to harm the health and comfort of occupants and may result in damage to the structural work of the dwelling. It is now widely recognised that without proper ventilation, indoor air can be as much as 8 times more polluted than outdoor air.

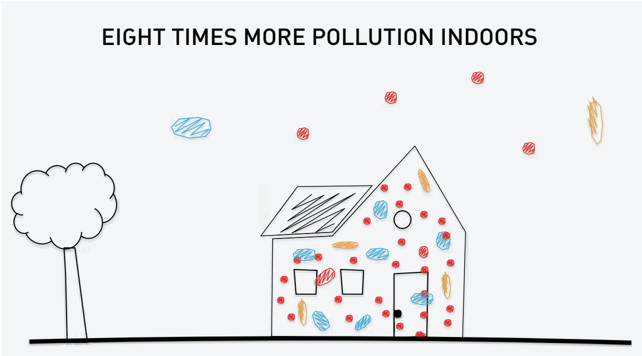


Figure 1: Pollution of indoor and outdoor environment ©ALDES

1.1.2 Ventilation air

Human presence is the major factor impacting ventilation air rates. The body uses oxygen from inhaled air to produce energy and emits water vapor and carbon dioxide (CO_2) upon exhalation. The main challenge to providing adequate indoor conditions is to prevent the accumulation of this water vapor and CO_2. High concentrations of CO_2 or relative air humidity cause discomfort and may be noxious to health and wellbeing. If the relative humidity is sufficiently high (> 70%), there is an unacceptable risk of condensation and mould growth on surfaces with temperatures near or below the dew point temperature in the air. Mould produces spores carried in the air, further damaging air quality in the dwelling to the detriment of people's health.

Ventilation reduces CO_2 concentration and moisture content of the indoor air by diluting it with outdoor air, which generally has a lower CO_2 concentration and absolute moisture content.

A correctly designed ventilation system must be able to provide sufficient outdoor air based on the number of occupants and their activities to ensure good air exchange and good Indoor Air Quality, so as not to harm the occupants.

1.2 WHY MECHANICAL BALANCED VENTILATION?

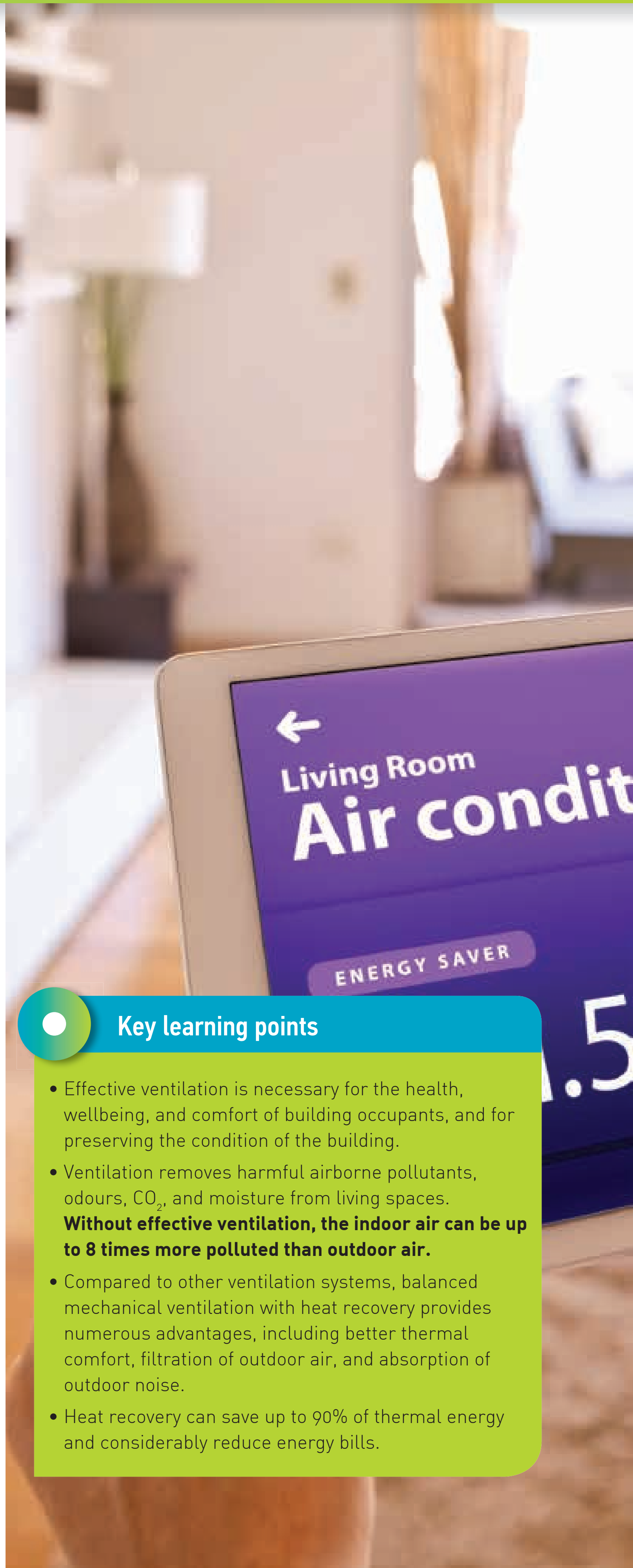
There are different systems of residential ventilation, like natural ventilation, exhaust mechanical ventilation, and balanced mechanical ventilation. However, only the latter type – mechanical balanced ventilation, in which both supply and exhaust air flows are forced by fans – provides the following essential advantages:

- Fully controlled supply and exhaust of air in selected rooms
- Very effective ventilation of the entire living space
- Low sensitivity to infiltration
- No direct inlets of outdoor air to the rooms, resulting in:
  - Absorption of outdoor noise
  - Filtration of the outdoor air supplied to rooms
  - Preheating of the outdoor air supplied to rooms
- Heat and moisture (optionally) recovery from exhaust air

1.3 WHY HEAT RECOVERY?

In winter and parts of spring and autumn as well, the outdoor air supplied to the building must be heated up. To save energy for its heating and reduce running costs, the energy contained in the warm and humid extract air is recovered to the cold outdoor air in a heat exchanger inside the ventilation unit. Similarly, during the summer the exchanger cools the hot outdoor air. Thanks to heat recovery, balanced ventilation systems help save up to 90% of thermal energy and ensure thermal comfort due to pre-heating of the air.

The advantage of heat recovery is such that in most cases a building would be unable to meet the strict energy performance demands in European and national building regulations without an effective heat recovery ventilation system.



Key learning points

- Effective ventilation is necessary for the health, wellbeing, and comfort of building occupants, and for preserving the condition of the building.
- Ventilation removes harmful airborne pollutants, odours, CO_2, and moisture from living spaces. **Without effective ventilation, the indoor air can be up to 8 times more polluted than outdoor air.**
- Compared to other ventilation systems, balanced mechanical ventilation with heat recovery provides numerous advantages, including better thermal comfort, filtration of outdoor air, and absorption of outdoor noise.
- Heat recovery can save up to 90% of thermal energy and considerably reduce energy bills.

2. DETERMINATION OF VENTILATION AIRFLOW RATE

For the balanced systems with heat recovery, ventilation supply and extract airflow rates are sized for all rooms with terminal devices. Outdoor air is normally supplied to habitable spaces (living rooms, bedrooms) and extracted from wet spaces (kitchen, bathrooms).

The minimum ventilation airflow rates are specified in many national regulations. These requirements must be observed in the first instance when designing a ventilation system. At European level, the fundamental ventilation requirements are given in EN 16798-1:2019 which provides basic ventilation rates per person in three indoor climate quality categories. This standard is followed in most countries, but as the difference between typical good indoor climate category II and that of satisfactory category III fluctuates across various national regulations, the values may vary significantly. Outdoor airflow rates per person are as follows EN 16798-1:2019:

- 10 l/s (36 m^3/h), per person in Category I
- 7 l/s (25,2 m^3/h), per person in Category II
- 4 l/s (14,4 m^3/h), per person in Category III

i 1 l/s = 3,6 m^3/h

These values form the basis for ventilation system sizing together with the evidence-based objective of achieving an average air change rate for a whole residence of 0,5 air changes per hour (ACH). The guidelines for airflow rate calculations set out in this Guidebook are based on the standard for **Category II** of good indoor climate. This may lead to slightly higher air change rates compared to some national regulations.

The challenge for ventilation sizing is that usually the designer does not know how many people will occupy a residence and specific rooms. The default assumption is that two people can occupy every bedroom. However, the supply airflow rate depends on the bedroom size as the probability of having two occupants is lower in smaller, and higher in larger, bedrooms. Similarly extract airflow rates have some dependency on occupant number or apartment size, being slightly lower in smaller apartments.

The ventilation supply airflows to the bedrooms and living rooms are expressed as an outdoor airflow rate supplied to the rooms. It is important to supply the outdoor air primarily to living rooms and bedrooms. The ventilation air for the kitchen, bathroom, and toilet has to be transfer air from the bedrooms and living rooms. Doors or specific openings should allow transfer airflows without significant pressure loss. From wet rooms, extract airflows are needed to remove pollutants and humidity.

Following the REHVA Residential Heat Recovery Ventilation Guidebook, the recommended minimum design supply and extract airflow rates are shown in Table 1. The values in the table assume complete mixing in the room (concentration of pollutants is equal in exhaust and in occupied zone). When designing, these values must be counterchecked with possible national requirements.

Table 1: Recommended minimum airflow rates in residences (based on REHVA Residential Heat Recovery Ventilation Guidebook)

	Supply airflow rate l/s	Extract airflow rate l/s	Air velocity[1] m/s
Living rooms[2] > 15 m^2	8+0,27 l/(s·m^2)		0,10
Bedrooms > 15 m^2	14		0,10
Living rooms and bedrooms 11-15 m^2	12		0,10
Bedrooms < 11 m^2, 3rd and successive bedrooms in large apartments	8		0,10
WC		10	
Bathroom		15	
Bathroom in one room apartment		10	
Utility room		8	
Wardrobe and storage room		6	
Kitchen[3]		8	
Kitchen[3], one room apartment		6	
Kitchen, cooker hood in operation		25	
Average airflow rate of a whole residence l/(s·m^2)[4]	0,42		
Staircase of an apartment building, ACH	0,5		

1 Maximum air velocity values apply at the design airflow rate and supply air temperature in heating season conditions, in boost mode higher velocities may be accepted
2 Transfer air from bedrooms may be reduced, 12 l/s is the minimum value
3 Airflow rate in the kitchen when cooker hood is not in operation
4 The airflow rate 0,42 l/(s·m^2) correspond to 0,6 ACH when the ceiling height is 2,52 m

2.1 AIR FLOW RATES FOR UNOCCUPIED PERIOD AND DEMAND CONTROLLED VENTILATION (DCV)

The design values of ventilation as presented in Table 1 assume continuous operation of the ventilation systems during occupied hours. A minimum ventilation rate should be provided for a residence even during unoccupied period to flush out the emissions from building materials and consumer products. The required ventilation rate depends on the pollution load from building itself and local conditions. A value of 0,1 l/(s·m^2) can be used as a default if more accurate assumptions are not available. If ventilation is controlled by air quality (CO_2 for occupancy detection) or humidity (in the bathrooms) the maximum design ventilation rate has to correspond to the values provided in Table 1.

2.2 TRANSFER AIR

Depending on the floor plan, air supplied to bedrooms may serve the living room as transfer air. Air transferred from bedrooms may be subtracted from living room supply airflow rate, however the minimum value of the supply airflow rate is 12 l/s. Supply airflow rate in larger living rooms is calculated as a function of floor area. The bedroom value of 14 l/s allows for two persons in bedrooms larger than 15 m^2. In large apartments or houses, 8 l/s may be used for the third and subsequent bedrooms which are assumed to be designed for one person. If the smallest bedrooms (8 l/s) are occupied by two people, the airflow rate is 4 l/s per person that corresponds to satisfactory indoor climate category III.

2.3 CONSIDERATION OF COOKER HOOD IN THE VENTILATION AIR BALANCE

The minimum requirement for cooker hood operation is 25 l/s and is particularly significant in the smallest apartments. In larger apartments, the cooker hood boost airflow value of at least 30 l/s is recommended as it leads to 75% odour removal efficiency in the case of effective hoods (typically meeting the needs of a reasonably large air volume). A more accurate way to determine the required boost airflow rate is to use the airflow of a selected hood product that gives 75% odour extraction, as recommended in standard EN 13141-3. To achieve required cooker hood operation, other extract airflows can be reduced, or the ventilation unit can be boosted (airflows are borrowed from other extract terminals). In new airtight buildings it is important that the cooker hood airflow is compensated, which is to say that total extract and supply airflow rates should be roughly equal in order to avoid excessive negative pressure in the building. The negative pressure caused by a non-compensated cooker hood will depend on the building leakage rate, as in Figure 2.

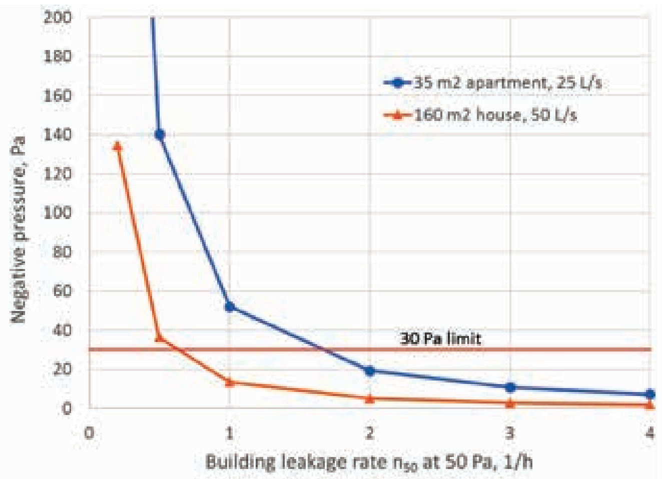


Figure 2: Negative pressure generated by non-compensated cooker hoods, with flows of 25 l/s in a 35 m² apartment and 50 l/s in a 160 m² house, as a function of building leakage rate n50. Typical n50 values in modern airtight buildings are below 1 (1/h). 30 Pa pressure difference limit (children cannot open doors) indicates that cooker hoods must be compensated in new buildings. ©REHVA

2.4 DESIGN AIRFLOW RATES IN MODEL APARTMENTS

The values in Table 1 lead to different total supply and total extract airflow rates which should be balanced so that the lower value is increased to equal the higher value. The case studies for balancing airflows in a one-bedroom apartment, a three bedrooms apartment and a detached house with 4 bedrooms are presented in Annex I.

Key learning points

- Guidelines for ventilation airflow rates are set out in EN 16798-1:2019. The recommended values must be verified against possible minimum requirements of national regulations that must be observed in the first instance.
- The standard provides minimal ventilation airflow rates to be supplied to habitable spaces and extracted from wet rooms. The supply and exhaust air must be balanced. Air supplied to bedrooms may be used to ventilate living rooms (transfer air).
- Air periodically exhausted by the cooker hood must be correctly accounted for in the ventilation air balance and system operation.

3. BASIC PRINCIPLE OF VENTILATION

A balanced mechanical ventilation system with heat recovery allows a very effective ventilation of the entire living space. One can distinguish between supply air, overflow, and exhaust air spaces. In supply air rooms, such as bedrooms and living rooms, the conditioned outside air is supplied, ensuring high air quality. In extract air rooms, such as kitchen, bathroom and toilet, the pollutants and moisture are removed. Depending on the circumstances (such as floor plan layout, refurbishment or new construction, etc.) the following air distribution within a dwelling can be put in place using balanced mechanical ventilation with heat recovery.

3.1 STANDARD CASCADE VENTILATION

This is the standard layout with supply air being delivered to all bedrooms and the living room. The corridor acts as an overflow zone, and the air is extracted in a kitchen, bathroom, and toilet. The overflow of air from one room to the next needs to be ensured even with closed door. In its simplest form, a door undercut of about 1 cm is sufficient. As a rule of thumb, the pressure loss should be < 2 Pa.

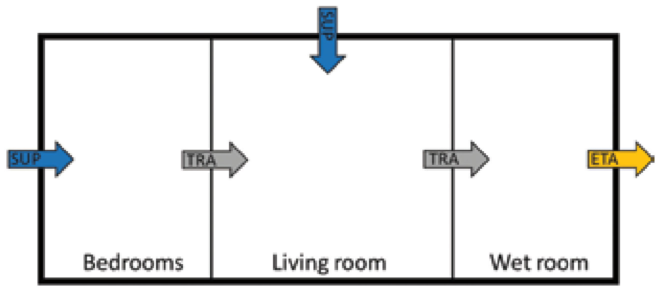


Figure 3: Layout of standard cascade ventilation ©J. Pichler GmbH

As Figure 3 shows, supply air (SUP) is delivered to bedrooms, living rooms or other common rooms, while the same amount of air is extracted (ETA) from the wet rooms (bathroom, toilet, and kitchen). The transfer air (TRA) passively flows from supply air rooms to wet rooms via overflow openings (e.g. door undercuts).

3.2 EXTENDED CASCADE VENTILATION WITH TRANSFER AIR

If the floorplan allows (see Figure 5), the living room can be treated as an overflow zone, thus reducing ductwork installation and total air flow. Since occupants are either in their bedroom or in the living room, omitting the supply air into the living room will not impair air quality. In regions with cold and dry winters, the reduction in air flow will reduce periods with low indoor air humidity. Many case studies have shown the applicability for many modern floorplans.

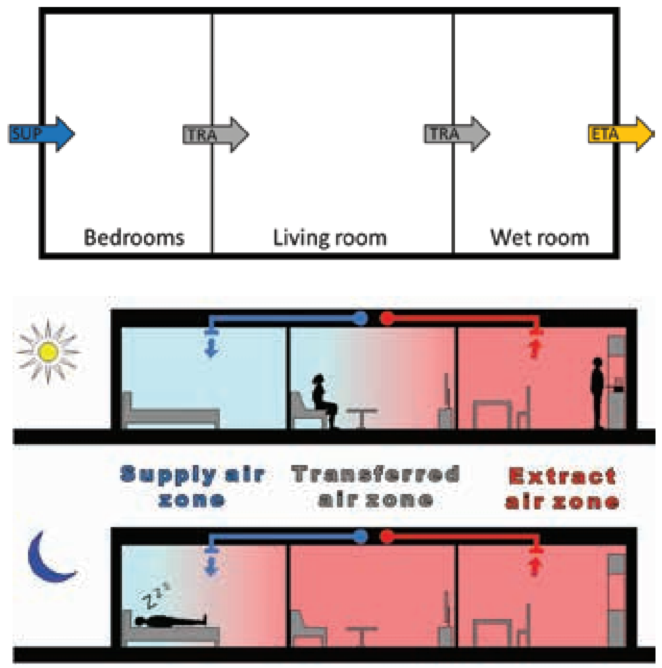


Figure 4: Layout of extended cascade ventilation ©J. Pichler GmbH (top) ©Elisabeth Sibille, University of Innsbruck (bottom)

The principle of extended cascade ventilation is illustrated in Figure 4. As shown on left side, the living room is solely supplied via transfer air from the bedrooms. This only works if the floorplan allows it (see Figure 5 below). On the right side, there is a visualisation of extended cascade ventilation. Under normal conditions, transfer air from bedrooms will be sufficient to dilute pollutants related to building materials and furniture. The occupant exposure to bio-effluents is not increased.

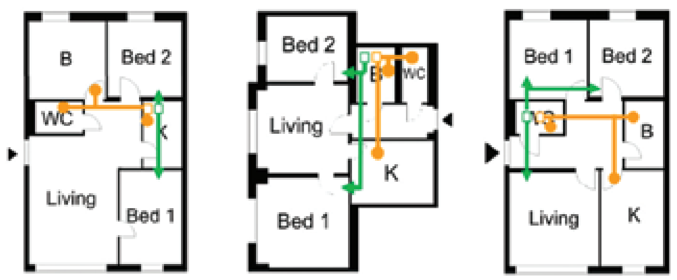


Figure 5: Floorplan examples where extended cascade ventilation (no supply air into living room) is possible (left and centre) and where supply air room into living room is required (right) ©Elisabeth Sibille, University of Innsbruck

3.3 ACTIVE OVERFLOW SOLUTION

For challenging refurbishment projects, where ducting cannot be routed to all rooms, the use of so-called overflow elements (AOE) can be a solution. For those rooms, one active and one passive overflow element is installed. The AOE will move air from the connecting room (corridor or living room) into the room in question and back out. In its minimal form, an AOE consists of a sound protected passage, a silent fan, and a control mechanism that ensures the fan is only running when the door of that room is closed. The AOE is often integrated in the door itself, which can simplify the refurbishment process. The connecting room (corridor or living room) must be well ventilated itself. The air is (partly) extracted from extract air rooms. This concept is less effective in terms of ventilation efficiency compared to cascading ventilation, as it mixes the air between all rooms (except extract air rooms).

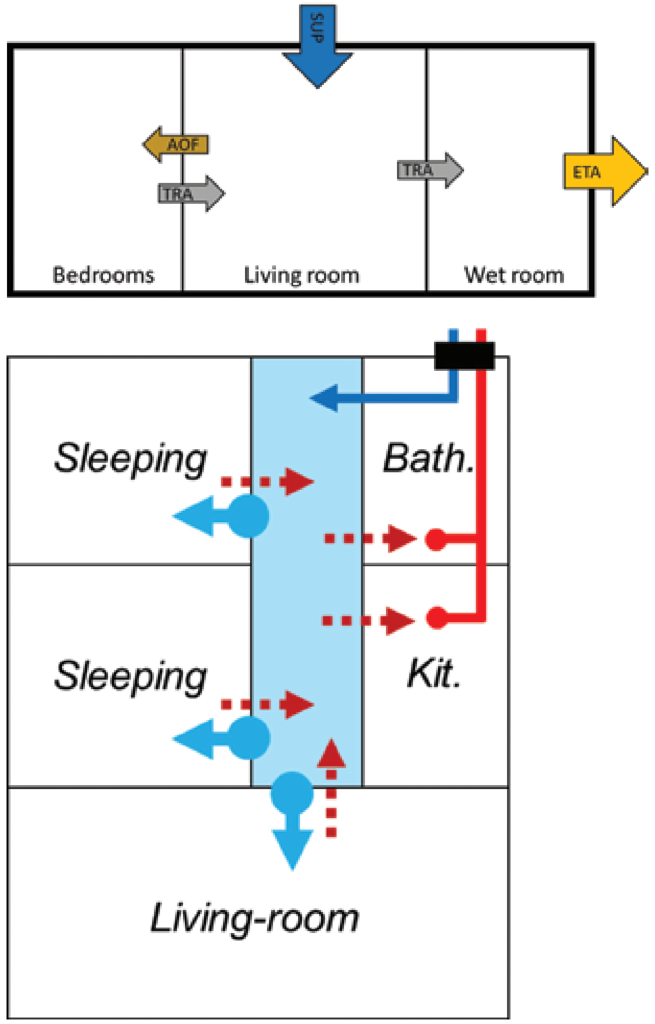
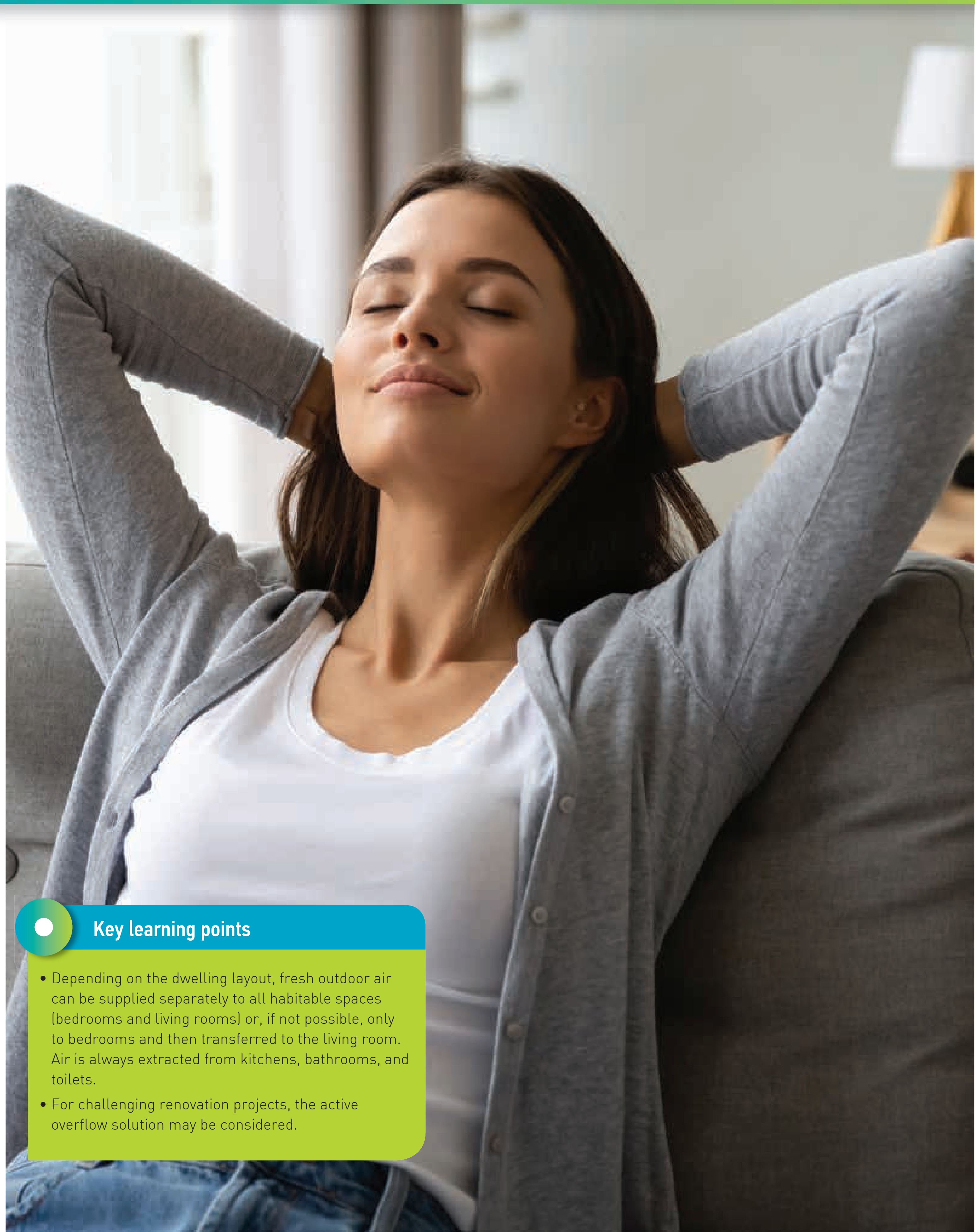


Figure 6: Layout of active overflow solution (top), example floor plan with active overflow elements used for both bedrooms and the living room (bottom). This way, ducting within the dwelling is greatly minimised. ©J. Pichler GmbH (top) ©Elisabeth Sibille, University of Innsbruck (bottom)



Key learning points

- Depending on the dwelling layout, fresh outdoor air can be supplied separately to all habitable spaces (bedrooms and living rooms) or, if not possible, only to bedrooms and then transferred to the living room. Air is always extracted from kitchens, bathrooms, and toilets.
- For challenging renovation projects, the active overflow solution may be considered.

4. VENTILATION NOISE

The noise from ventilation systems may disturb the occupants and prevent or detract from the intended room use. The noise in a space should be evaluated using A-weighted equivalent sound pressure level, normalised with respect to reverberation time ($L_{Aeq,nT}$) to take into account the sound absorption of the room. $L_{Aeq,nT}$ is defined in ISO EN 16032 and EN ISO 10052.

The sound pressure level in a room depends on the total noise entering the room space. Often the noise criteria are given for the total noise generated by the HVAC system (as in standards ISO 17772-1 and EN 16798-1:2019). It is recommended to design the ventilation system noise level a few dB lower than the criteria for total HVAC noise level due to the combined effect of all sources. People are more sensitive to noise in a quiet residential environment compared to an office environment, therefore EN 16798-1:2019 category I noise levels are recommended to be used as the design criteria, as in Table 2.

Table 2: HVAC systems continuous sound level at design airflow rate during the heating season. To apply these values for ventilation systems only, the heating system must not generate noise in residential rooms.

Design equivalent continuous sound level, $L_{Aeq,nT}$	dB(A)
Bedroom	25
Living room[1]	30
Wet room[2]	35

1 The requirement does not apply during cooker hood operation in an open plan living room forming a same room with kitchen.
2 The requirement does not apply for the noise through the casing of the ventilation unit, where the maximum level can be 45 dB(A).

The values in Table 2 can be exceeded for a short period if the occupants can control the operation of the equipment, boosting the ventilation of the apartment or a room or operating the cooker hood or kitchen exhaust fan. However, the rise of the sound pressure level over the values in the table should be limited to between 5 and 10 dB(A).

4.1 RELATION BETWEEN SOUND PRESSURE LEVEL AND SOUND POWER LEVEL

The sound pressure level is a physical measure directly impacting the human ear. It is used for setting noise limits (see Table 2). In turn, the sound power level is a measure for testing the acoustic performance of ventilation equipment. This value is normally declared in the technical documentation of a product. The sound power level can be converted to the sound pressure level with consideration of a distance to a noise source and the sound absorption of the room.

The absorption of the room surfaces has a significant effect on the sound pressure level created by a certain sound power in the room. The sound pressure level from a specific sound power is lower in a room with soft absorbing surfaces. Often equipment suppliers indicate the sound pressure for equipment assuming a total absorption of the room to be 10 m^2 Sabin, which corresponds to 4 dB sound absorption, which is to say 4 dB lower sound pressure level than the sound power level. In empty rooms, the sound absorption may be less: only 1-2 dB instead of 4 dB. In wet rooms, sound pressure level is often equal to sound power level: there is no significant absorption in a small room with hard surfaces. However, at the design stage, the sound absorption characteristics of a room are usually not known. Therefore, in practice, it is safer to define the sound pressure level in an empty room.

4.2 SOURCES AND ELIMINATION OF VENTILATION NOISE

4.2.1 Noise due to airflow

Airflow in a ventilation system ductwork may cause noise. The principle is simple: the higher the air velocity and the number of obstacles in the airway, the higher the noise. For this reason, the air ducts must be large enough to avoid excessive noise and pressure drops caused by high air velocity. Table 3 provides the recommended maximum air velocities for different parts of supply ductwork. Generally, higher velocities are tolerated in circular ducts compared to rectangular ones. However, larger dimensions are preferred in places where airflows collide with air duct walls. Extract grilles are usually located in rooms with less stringent noise limits compared to those of living rooms and bedrooms, and so higher air velocities are allowed in extract air ducts. In addition, increased velocities can be tolerated between air handling units and sound attenuators and in ducts connecting the air handling unit to the outdoor air.

Table 3: Air velocity limits in supply air ducts of dwellings

	Maximum velocity, m/s	Airflow rate at maximum velocity, l/s					
		Ø100	Ø125	Ø160	Ø200	Ø250	Ø315
Air ducts in the apartment after sound attenuators	2,5	20	31	50	79	123	195
Rectangular ducts (area corresponding to Ø)	3	24	37	60	94	147	234
Circular ducts	4	31	49	80	126	196	312
Circular main ducts[1]	5	39	61	101	157	245	390

1 In vertical main ducts of apartment buildings

4.2.2 Noise of ventilation unit

Ventilation sound pressure in rooms is directly dependent on the sound power of fans in the ventilation unit. Usually, to reduce the noise, sound attenuators must be installed in the ductwork between a ventilation unit and air inlets or outlets in the rooms. In principle, the selection of silencer should be based on the unit's acoustic performance in mid-frequency of octave bands, However, the critical frequency is 125 Hz and this knowledge supports the rough selection of sound attenuators. A simplified method for indicative selection of sound attenuators is presented in Annex II.

4.2.3 Noise of outdoor air intakes and exhaust air outlets

Noise may also travel from an intake or exhaust opening of an apartment to the balcony of an adjacent apartment or even through a neighbour's open windows. Limitations should be set to ventilation noise from ventilation equipment to outside. The noise level should not be more that 45 dB(A) at the balcony or at the neighbour's window. In the case of a higher noise level, sound attenuators should be installed in outdoor and exhaust ducts.

4.2.4 Sound transfer in between rooms

Sound transfer between apartments and rooms must be considered as well as noise from ventilation units. Requirements have been set on sound insulation of structures and this must not be deteriorated by ventilation ductwork. Generally, the limit values for airborne noise insulation index R'w are:

- Between apartments: R'w ≥ 55 dB
- Within an apartment (internal ceilings in a multi-storey apartment, internal walls without doors): R'w ≥ 43 dB

Sound may transfer from one room to another through ventilation ducts and this problem may be particularly serious if sound transfers between apartments. In order to calculate the noise insulation index of the ductwork the attenuation must be determined.

The sound insulation index criterion of structures in an apartment can be achieved with various solutions if there are no openings or doors in the structure. If two adjacent rooms have doors to a corridor, then the sound insulation decreases by approximately 3-5 dB, when doors are closed. Thereby, occupants could expect a sound insulation index R'w ≥ 39-37 dB (based on experience) and the ventilation system should not damage that.

If higher sound insulation between rooms is required, special doors, air transfer dampers and sound attenuators on air ducts should be used

Key learning points

- Necessary measures must be taken at the design and construction phase to ensure that the sound pressure level in the rooms is within accepted limits.
- The ventilation system noise is mainly caused by the airflow in ductwork and fans of the ventilation unit. Noise in the ductwork can be eliminated by limiting air velocity. To eliminate the noise of fans, normally sound attenuators must be installed in the ductwork between a ventilation unit and air inlets or outlets in the rooms.
- The absorption of the room surfaces (wall, furniture etc.) has a significant impact on the sound pressure level. Rooms with soft surfaces offer higher sound absorption. In empty rooms, the sound absorption may be considerably lower.
- The transfer of noise between rooms and emission of noise to the outdoor environment (through outdoor air inlets and exhaust air outlets) must also be considered.

©J. Pichler GmbH

5. REQUIREMENTS FOR SYSTEM COMPONENTS

5.1 INSTALLATION OF THE VENTILATION UNIT

When planning the residential property, the space requirements for the ventilation units and their components as well as the required wall and ceiling ducts must be considered. When choosing the location of the ventilation unit, consideration must be given to aspects of sound insulation and energy efficiency. For reasons of sound protection, the ventilation unit should not be located directly adjacent to sleeping rooms.

In principle the unit can be placed outside or inside if the respective parts of the unit housing are adequately protected and insulated. In any case, the device should be placed as close as possible to the thermal building envelope to avoid lengthy ductwork that needs insulation. If cold ducts are routed within the thermal envelope, a water vapour diffusion tight insulation needs to be used. For units that produce condensate during operation (i.e. heat exchangers without humidity recovery) a drainpipe must be provided. If the installation is not frost-free, suitable measures must be taken. Ensure easy access to the ventilation unit for service, cleaning, and maintenance.

5.2 ARRANGEMENT OF AIR INLET AND OUTLET

In principle, the supply air inlet can be positioned anywhere in the room. To reduce ductwork and ensure that no furniture is placed in front of the inlet, the position near the ceiling above the bedroom door has proven in practice as a good choice. Due to the Coande effect, the air is distributed into the room and no short-circuit occurs even if the overflow element is just below in the door. Supply air inlets should not be located near to beds, sofas, and such, so that no disturbing drafts can occur.

Extract air outlets should be located in areas where moisture and odours are generated.

The air outlets and inlets must be easy to clean, and their throttling devices must be smooth.

The outdoor air intake and exhaust air outlet need to be positioned so that weather-related influences (e.g. rain, snow depth, moisture) do not impair the function of the system. Additionally, outside air inlets should not be located where exhaust air, contaminants from external sources (e.g. cars, garbage containers, etc.), or excessive heating (e.g. south façade) are expected. Furthermore, it should be noted that the arrangement and distance of the outdoor air intake and exhaust air outlet may be subject to local building regulations.

5.3 AIR DUCTS

5.3.1 General guidelines

Air ducts must be made of materials that can be subjected to mechanical stress. They must be corrosion-resistant, abrasion-resistant, and smooth on the inside. Guiding the air through shafts or conduits that are brick-lined or are exposed to insulation material or any other non-smooth material is inadmissible. The ductwork should be designed in a way to facilitate its periodic cleaning.

Due to hygienic reason (difficulty of cleaning) and high pressure drop, the use of flexible aluminium pipes should be limited only to short sections connecting the rigid duct with air inlets or outlets. Making the entire ductwork of flexible aluminium or plastic pipes should be strictly avoided.

In principle, a common duct can be provided for residential properties with several individual systems for the outside air and exhaust air. In that case, it must be ensured that during operation of the individual systems, no reversal of the flow direction can occur due to the variable pressure conditions in the system (prevention of odour transmission). This solution may be restricted in national and local regulations. Air ducts should be as short as possible.

Attention is drawn to the measures required for the routing through fire zones. Check national and local requirements.

If rooms are connected by air ducts or overflow openings, measures must be taken to reduce telephony sound.

5.3.2 Thermal insulation of ducts

To avoid condensation of moisture and heat losses, the duct must be thermally insulated. If an improperly insulated duct with warm and humid air is routed through a cold area, the temperature of the transported air decreases, and condensation occurs on the inner surfaces of the duct. Similarly, if a duct with cold air is routed through a warm and humid environment, condensation occurs on its external surfaces. Thus, if the ventilation unit is installed inside the building, a section of outdoor air duct (from the building envelope to the ventilation unit) and a section of exhaust air duct (from the unit to the building envelope) must be thermally insulated. In turn, if the unit is installed outdoor, the sections of supply air and extract air ducts routed outside must be insulated.

5.3.3 Air tightness of ducts

Air tightness of ductwork is essential both for energy efficiency and hygiene. If ducts are not airtight, not all ventilation air reaches its destination. This means that fans must run at higher speed and consume more energy. In turn, if a duct with negative pressure inside is located in a dirty environment (e.g. in the attic), the ambient dust can be sucked into the duct, polluting the duct and ventilation unit. Thus, it is very important to use high quality ductwork system components and take care about proper standard of workmanship.

5.4 PROVISION OF CLEANING

Ensuring a clean ventilation system is important for Indoor Air Quality, fan power consumption, and for fire safety aspects. The aim should always be to avoid any contamination, to avoid or reduce required cleaning activities. Therefore, the system and components should be protected from contamination and soiling during construction.

Accessibility to the system components for maintenance and cleaning must be ensured. During design phase, it needs to be considered, that cleaning of all duct segments including cross-sectional reducing elements and duct branches can be carried out without structural intervention. The access to clean the ducts inside can by ensured by inspection hatches or through air inlets and outlets. The general guidelines for the access requirements can be found in EN 12097 standard. The appropriate hygienic measures may by also addressed in local regulations.

6. KITCHEN VENTILATION – COOKER HOOD

A kitchen hood (also called as a cooker hood) is very important for ensuring a good indoor climate in a home. Kitchen hoods can be categorised into several different system solutions:

- Extracting device, exhausting the kitchen fumes via a fan and ducting directly to the outside
- Recirculating device, exhausting the fumes, after filtration, back into the kitchen
- Device connected to the home ventilation system, exhausting the fumes via the ventilation system (with heat recovery) to the outside

Note: Check national building regulations, as not all solutions might be allowed in every country. Local requirements may exist.

Many design variants exist like wall mounted, under the cabinet, island hoods, downdraft devices, etc. They all have in common that they include a grease filter to reduce grease condensate from the fumes and often a light for convenience.

Figure 7: Examples of standard cooker hood without fan, but with grease filter, damper and light. ©Exhausto A/S

©ALDES

6.1 EXTRACTING DEVICE

This is usually the most effective way to remove cooking fumes, as high extract air flows can be realised. Typical values range from 200 up to 500 m³/h (i.e. 50 to 150 l/s). However, this concept has the highest ventilation losses as the same amount of air will be drawn in from the ambient to replace the exhausted air. The below aspects need to be considered when installing an extracting device.

6.1.1 Extract air opening

When the cooker hood is not in use, the opening should minimise thermal losses due to infiltration and thermal bridging. Insulated, airtight products that only open when necessary are available.

6.1.2 Compensation of extract air

When the cooker hood is in use, reduce exhaust air flow rate of a ventilation unit and/or boost supply air flow (see chapter 2.3). If this is not possible, consider make-up opening.

6.1.3 Make-up air opening

The high extract air flows would strongly depressurise the kitchen / dwelling if no make-up air opening is foreseen in modern airtight buildings. This can cause problems with the operation of a balanced mechanical ventilation system. Therefore, the free inflow of make-up air needs to be ensured whenever the cooker hood is active. This can implement in form of a window switch, that only allows the operation of the hood if a nearby window is open or tilted. The other option is the installation of dedicated make-up air opening. Products which ensure air tightness when not in use and minimise thermal bridge effects are available.

6.2 RECIRCULATING DEVICE

Recirculating cooker hoods are very simple to install as they do not need any ducting and the building envelope does not need to be penetrated. However, all cooking fumes and humidity generated during cooking stay in the dwelling. Devices with charcoal filters can remove odours, but they will not necessarily remove fine and ultrafine particulate matter generated by certain cooking activities. The below aspects need to be considered when installing a recirculating device.

6.2.1 Filter

Make sure devices with a sufficiently large charcoal filter are used to ensure decent odour removal performance.

6.2.2 Humidity removal

Recirculating devices should only be used if the kitchen is continuously ventilated, for example by a mechanical ventilation with heat recovery. The ventilation system and in particular the extract air flow in the kitchen should be designed to provide sufficient air exchange to keep average indoor air humidity at desired levels.

6.2.3 Gas stoves

It is not recommended to use recirculating cooker hoods in combination with gas stoves, due to harmful pollutants from gas combustion.

6.3 DEVICE CONNECTED TO CENTRAL VENTILATION SYSTEM

Interestingly, this solution is implemented very often in certain countries (e.g. Scandinavian countries) but not at all in other countries (e.g. Central European countries), where national standards explicitly rule out this solution.

As some grease will usually pass the filters and get into the ducting system and even in the ventilation unit, the below aspects need to be considered when incorporating the cooker hood into the ventilation system:

- For units with a counter flow heat exchanger (the most common), the air can go directly into the unit and heat recovery device
- For units with a rotary heat exchanger, it is normal to make a by-pass inside the unit, letting the cooker hood air by-pass the heat recovery (see Figure 8)

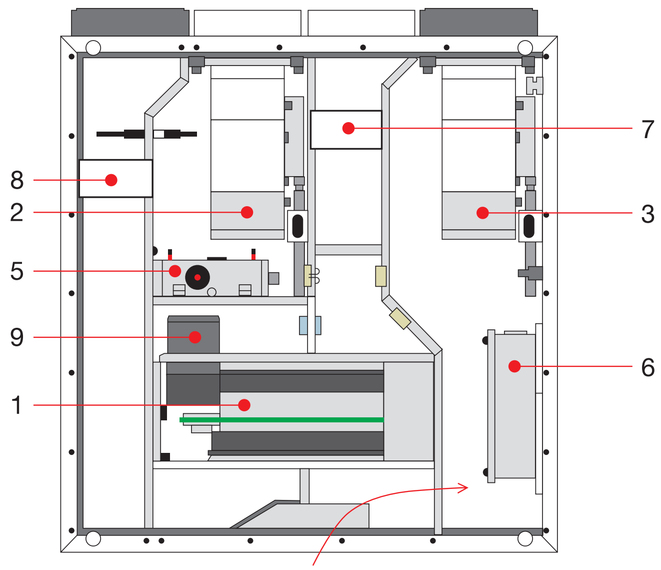


Figure 8: Cooker hood by-pass ©SALDA UAB

PART 2:
TYPICAL SYSTEMS FOR RESIDENTIAL VENTILATION WITH HEAT RECOVERY

7. SYSTEMS FOR DETACHED AND SEMI-DETACHED HOUSES

When planning new buildings, aspects related to the ventilation systems should be taken into account and implemented. In detached and semi-detached houses, the building is supplied with fresh air from the outside. The ventilation system consists of a ventilation unit with filter and heat recovery and an air ductwork. In the ventilation unit, the outside air is filtered and possibly preheated.

The preheating can be done electrically or via a geothermal heat exchanger. The supply air is introduced into living rooms and bedrooms. The supply air enters the bathrooms, toilets, and the kitchens via the corridor. This exhaust air is transported back to the ventilation unit and heats the fresh air via the heat exchanger. Then the exhaust air is released into the ambient air (see Figure 9).

The installation of a ventilation unit in detached and semi-detached houses can be done both on the ceiling and on the wall. If permitted by local regulations, in multi-storey buildings the fresh and exhaust air can be collected via lines in the riser shaft for several dwellings.

Systems for detached and semi-detached houses offer the following advantages:

- Simple flow control and accurate volumetric flow balance
- Lower planning effort
- Short air ductwork lines and lower pressure losses
- Space saving, no technical room necessary
- Accurate billing
- Good integration of the ventilation unit with the smallest possible space requirement, reduces investment costs and creates more living space
- Compact units, components, and air distribution, which are suitable for quick and easy installation, reduce the structural complexity
- Installation of cost-effective components and ready-made system solutions that reduce on-site installation costs

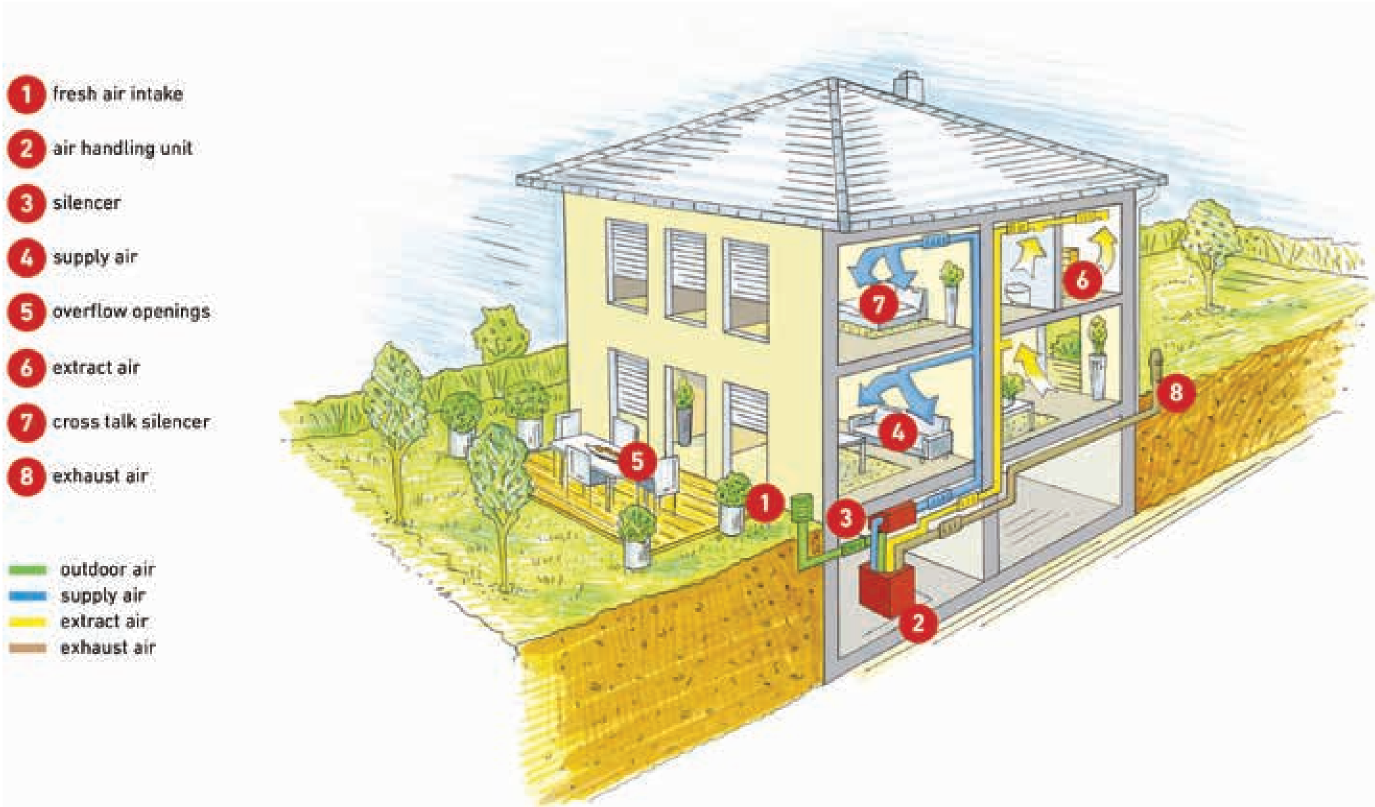


Figure 9: Air handling unit in detached and semi-detached houses ©J. Pichler GmbH

8. FACADE INTEGRATED APPROACH WITH OR WITHOUT SECOND ROOM CONNECTIONS

In the case of facade integrated ventilation units, a supply air fan conveys the outside air into the rooms via a filter and a heat exchanger, and a second fan conveys the exhaust air that has been used to the outside via the heat exchanger. Facade integrated units could also be equipped with a second room connection to integrate additional rooms, as in Figure 10 and Figure 11.

For renovations and sometimes for new buildings, central ventilation for the entire building or apartment is often too expensive. In this case, room-by-room solutions can be implemented. This approach can also be used for partial renovations. Here only core drillings and the power connection are necessary.

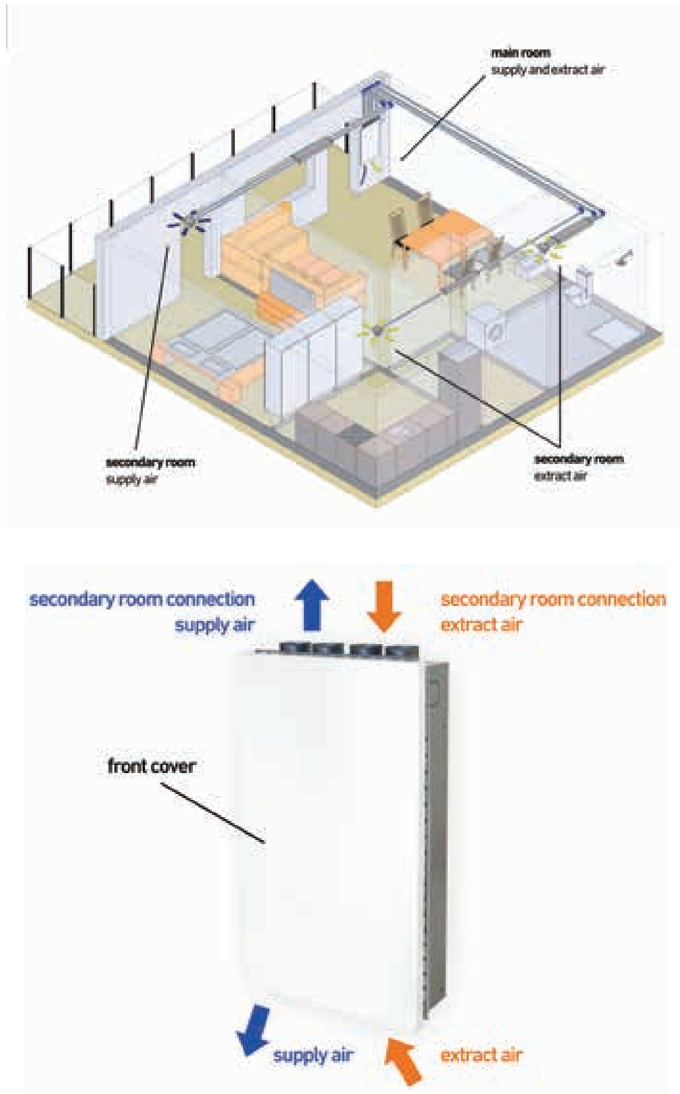


Figure 10: Facade integrated unit and its installation example ©J. Pichler GmbH

Due to short distances between inlets and outlets typical for this kind of units, a short circuit between supply air and exhaust air or extract air and outside air may occur.

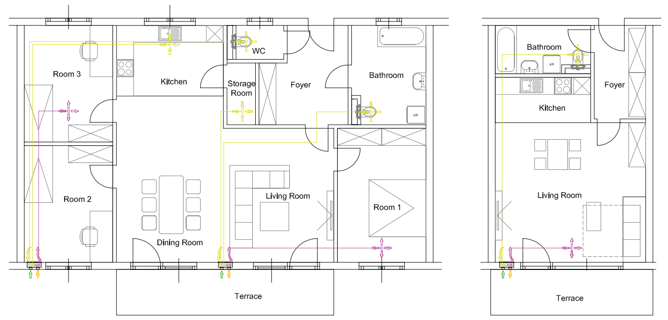


Figure 11: Facade integrated approach (left), facade integrated unit with a second room connection (right) ©J. Pichler GmbH

Facade integrated approach with or without second room connection offer the following advantages:

- Cost-effective and simple system solution for maintaining minimum hygienic requirements and moisture protection
- Installation in or on the outer wall allows the elimination of risers
- No penetration of fire sections in the residential building
- Versions with or without adjoining room connections are possible
- Room-wise air control possible
- Solution suitable for retrofitting
- No air pipes necessary
- Easy cleaning of the device

9. CENTRAL VENTILATION IN MULTI-STOREY BUILDINGS

Central ventilation systems consist of a ventilation unit serving several flats. In addition, volumetric flow controllers (VAV) may be installed in each apartment. The supply air is distributed to individual storeys via vertical manifolds. The installation of the ventilation pipes in the apartments can be done in concrete or under the ceiling (see Figure 12).

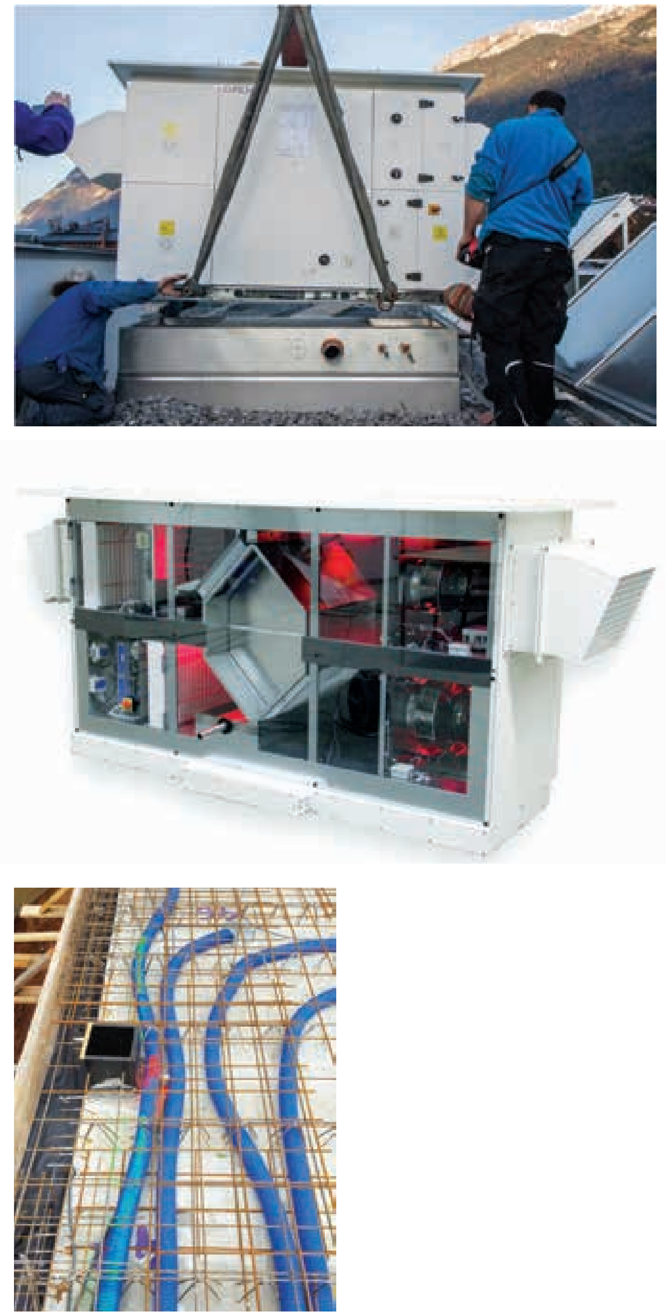


Figure 12: Scheme central ventilation units (top, middle), pipe laying in concrete (bottom) ©J. Pichler GmbH

The central system provides various options for airflow control, including constant flow rate, constant pressure control or pressure control with system optimiser. The control of airflow in apartments can be performed by means of the housing regulators, which can be equipped with silencers and cross talk silencers (see Figure 13).

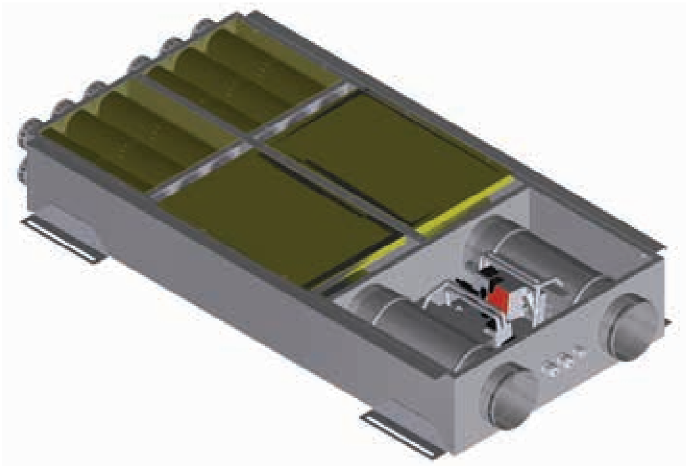


Figure 13: Example VAV-Box with silencer and cross talk silencer ©J. Pichler GmbH

The ventilation unit can be installed both inside and outside. Central ventilation system offers the following advantages:

- One ventilation unit for all dwellings with easy access for maintenance
- Facilitated scheduling of maintenance operation (no need for access to dwellings)
- Easy adjustment of airflow rates (if VAV boxes are used)
- Ability to adjust airflow rates to the actual demand (based on occupancy, CO_2, or humidity sensors)

©J. Pichler GmbH

PART 3:
RESIDENTIAL VENTILATION UNITS
WITH HEAT RECOVERY

10. GENERAL OVERVIEW OF RESIDENTIAL VENTILATION UNITS DESIGN

According to Eurovent Market Intelligence, over 150 manufacturers offer various types and models of Residential Ventilation Units on the European market. The main distinguishing features of these devices include the following aspects.

10.1 INSTALLATION

There are three types of units by installation type: wall-mounted, floor mounted, and suspended under celling. Most devices for floor mounting can be also suspended. Another group consists of units for facade mounting (in the external wall of a building).

10.2 CONNECTION OF DUCTS

Most units have circular spigots. Depending on the device size, the connection diameter ranges from 80 to 250 mm. The connections can be vertical (for standing and wall-mounted units) or horizontal. In case of horizontal arrangement, the connections to the building side (supply and extract) can be located on one side of the unit, and the ambient connections (outdoor air inlet and exhaust) on the other unit side. However, sometimes it is different. Thus, it is important to consider if the configuration of connections is correctly adjusted to the system ductwork layout.

10.3 AIRFLOW RANGE

Normally, the airflow rate of residential ventilation units ranges from 100 m³/h (for small apartments) up to 600 m³/h (for large, detached houses). This range is typically segmented into three unit sizes:

- Up to 150 m³/h
- Up to 350 m³/h
- Up to 600 m³/h

For central ventilation systems in multi-dwelling buildings, considerably bigger units can be used as well.

10.4 COMPONENTS AND FUNCTION

In general, all units include the following main components: supply and exhaust fans, heat recovery exchanger, outdoor and exhaust air filters, and integrated control system. For the vast majority of units, all components are embedded in a compact casing. There is however a group of units that must be assembled on site (separately supplied elements like a heat exchanger or fans to be integrated in the ductwork). In addition to the components mentioned above, some devices comprise elements like a heater (mostly electric) or cooker hood by-pass for heat exchanger. The following chapters outline the specification of components and their features, and the clarification how they impact the unit performance.

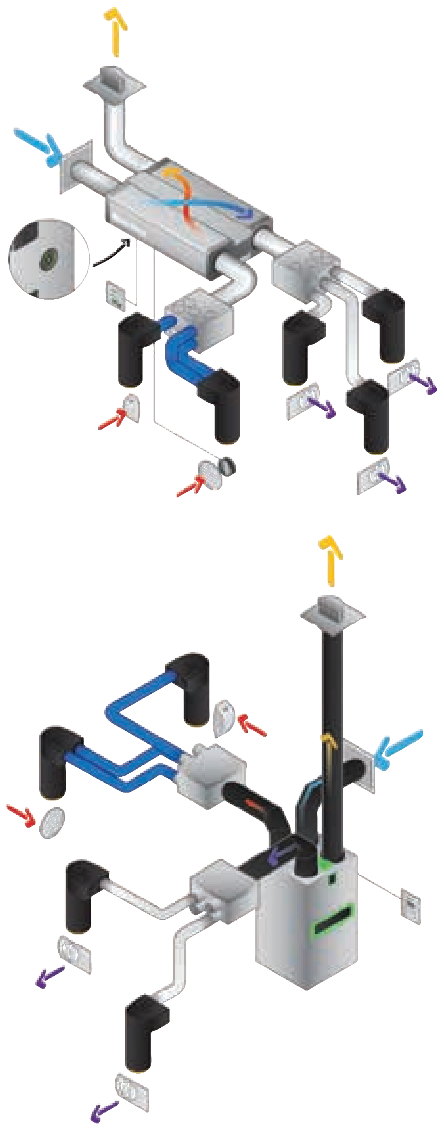


Figure 14: Samples of various residential ventilation units and installation in the system ©ALDES

11. COMPONENTS OF RESIDENTIAL VENTILATION UNITS

11.1 AIR FILTER

Air filters play an essential role in providing a good indoor climate. Residential ventilation units are equipped in supply and exhaust air filters. The supply air filter removes pollutants from the outdoor air before it is delivered to rooms. The main pollutant of outdoor air is particulate matter (PM). PM is a mixture of solid and liquid particles and droplets including pollen, bacteria, yeast, and moulds along with other organic and inorganic matter. Both the supply and exhaust air filters are also crucial to keep the inside of ventilation unit itself clean and ensure a hygienic operation of a ventilation system.

The classification of the filter efficiency rating is defined in the EN ISO 16890 standard. The classification distinguishes between the ISO Coarse, ePM1, ePM2,5 and ePM10 groups. A group shows for which particle size a filter is rated. For instance, an ISO ePM1 70% filter has a filtration efficiency of 70% for the removal of particle size 1 µm, while an ISO ePM10 50% filter has an efficiency of 50% for 10 µm particles. ePM1 filters are more effective (eliminate finer particles) than ePM2,5 filters, and these in turn are more effective than ePM10 filters. ISO Coarse filters are not able to filter out fine particles (below 10 µm), only larger ones. EN ISO 16890 replaced the former and obsolete EN 779 standard. The classification of EN 779 (e.g. G4, M5 or F7) cannot be directly converted to the ISO classification, but a rough estimation of how the old classes correspond to the new ones can be found in the Eurovent Recommendation 4/23 (for instance, M5 roughly corresponds to ISO ePM10 50 - 70%, F7 to ISO ePM1 50 - 75%, and F8 to ISO ePM1 65 - 90%).

11.1.1 Impact of particulate matter on human health

It is commonly known that air pollution is unhealthy, but it is not so well known that the smallest particles are the most dangerous. In fact, our upper respiratory tract can prevent coarse particles bigger than 10 µm from entering into our body. Smaller ultrafine particles can easily reach our lungs and even penetrate into our bloodstream.

In many locations, urban air is polluted by small PM_1 particles and gases coming from combustion and diesel engines, which city centres are crowded with. Bacterial and fungal spores, which are naturally present in the air, are typically in a size range between 1 and 10 µm.

To create healthy spaces indoors and to keep the inside of the unit itself clean, these particles must be filtered out of the outdoor air stream. Therefore, for most residential applications, ISO ePM1 supply air filters are recommended.

The main function of the exhaust air filter is to keep the inside of the unit itself clean. Thus, requirements for its efficiency are less demanding. Normally, ISO Coarse 60% or ePM10 50% filters are suitable.

11.1.2 Gas and odour contaminants

Besides particulate matter, outdoor and indoor air contains molecular or gas phase pollutants such as ground level ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and odours or volatile organic compounds (VOCs). If needed, these contaminants can be eliminated by carbon filters, also called gas phase filters.

A common solution is to use filters having in the same frame two layers of different media, one for particles filtration and the second for gas phase pollutants.

11.1.3 Selection of supply air filter class according to ambient air quality

It is essential to correctly match the filter class to the ambient air pollution to ensure the correct Indoor Air Quality. It stands to reason that the more polluted the ambient air, the better the filter needs to be. The quality of outdoor air (ODA) is categorised in EN 16798-3 based on the annual average concentration of PM_{10} and $PM_{2,5}$ particles in line with the WHO air quality guidelines:

Table 4: ODA categories according to EN 16798-3

Outdoor Air Category	PM_{10} annual average concentration	$PM_{2,5}$ annual average concentration
ODA 1	≤ 20 µg/m³	≤ 10 µg/m³
ODA 2	≤ 30 µg/m³	≤ 15 µg/m³
ODA 3	> 30 µg/m³	> 15 µg/m³

The outdoor air category in a specific location can be found online from global sources such as the WHO or the European Environment Agency or, even better, from local agencies monitoring the outdoor air quality.

As an indication, ODA 1 typically corresponds to a clean rural environment, whereas a typical ODA 3 environment would be a highly polluted urban area. Depending on the ODA category, Eurovent recommends using the following supply air filter in ventilation units:

- ODA 1 – ISO ePM1 50%
- ODA 2 – ISO ePM1 70%
- ODA 3 – ISO ePM1 80%

© TROX GmbH

11.1.4 Frequency of filter replacement

The filter service life is defined as the operating period between filter installation and filter replacement. If filters are not regularly and timely replaced, a range of issues are likely to follow including:

- Hygiene issues (e.g. microorganisms, fungal spores, odours)
- Excessive energy consumption
- Decrease of ventilation airflow rate
- Possible damage of filters

Residential ventilation units are equipped with a visual filter change warning signal. Most commonly, the warning triggers after a period set by the manufacturer. This time may be adjusted depending on the operating conditions, including outdoor air quality. The general recommendation is to replace filters at least once a year.

11.1.5 By-pass leakage

Even the best filter will not correctly serve its purpose if its assembly in the mounting frame is not airtight, and the air which needs to be filtered bypasses the filter media. This phenomenon is called by-pass leakage. Low by-pass leakages are achieved by quality unit design and workmanship.

Key learning points

- Air filters are crucial to ensure that air supplied to a dwelling is clean and healthy, but also to keep the inside of the ventilation unit clean and ensure the hygiene of the ventilation system.
- The class of the supply air filter should be adjusted to the quality of the outdoor air.
- Air filters must be replaced regularly and timely to avoid hygiene issues, excessive energy consumption, and decreased ventilation airflow rates.
- The original spare filters supplied by the ventilation unit manufacturer should be used for replacement. Unverified substitutes may not achieve the required performance in terms of filtration and energy efficiency.

11.2 HEAT RECOVERY EXCHANGER

The heat recovery exchanger is a key element of the residential ventilation unit. It transfers energy contained in the exhaust air to the stream of outdoor air. This energy would otherwise have been exhausted into the atmosphere and wasted. In this way, energy is reused or recovered to warm up (in winter or interim period), or to cool down (in summer) the ventilation air before it is supplied to the rooms. This considerably reduces the consumption of energy from external sources to condition the air, and in some cases even eliminates it. In addition, some types of exchangers provide recovery of moisture, which improves indoor environmental quality.

11.2.1 Types of exchangers

The two most common types of heat recovery exchangers in residential ventilation units are described below.

Recuperative heat exchangers (see Figure 15) recover heat via its fixed plates using thermal convection and conduction effect. Their advantages are air tightness and no moving parts. Depending on the air flow pattern, the exchanger can be crossflow or counter-flow type. The most thermally efficient exchangers are counter-flow ones. Recuperative heat exchangers normally do not recover moisture (humidity), except for the most advanced, so called enthalpic exchangers with moisture permeable plates.

Figure 15: Counter-flow exchanger ©2VV s.r.o.

Regenerative heat exchangers (see Figure 16) recover heat via its rotating wheels using thermal accumulation effect into mass. Their advantages are lower freezing limit, humidity recovery and efficiency controllable by rotation speed. The efficiency of moisture recovery depends on the wheel type. The condensation wheel features good moisture recovery in winter period, while the sorption wheel offers moisture recovery throughout the year.

Both types of exchangers have different features and advantages that might be important for the use of a residential ventilation unit. Important aspects to be considered depending on the application are outlined in the following chapters.

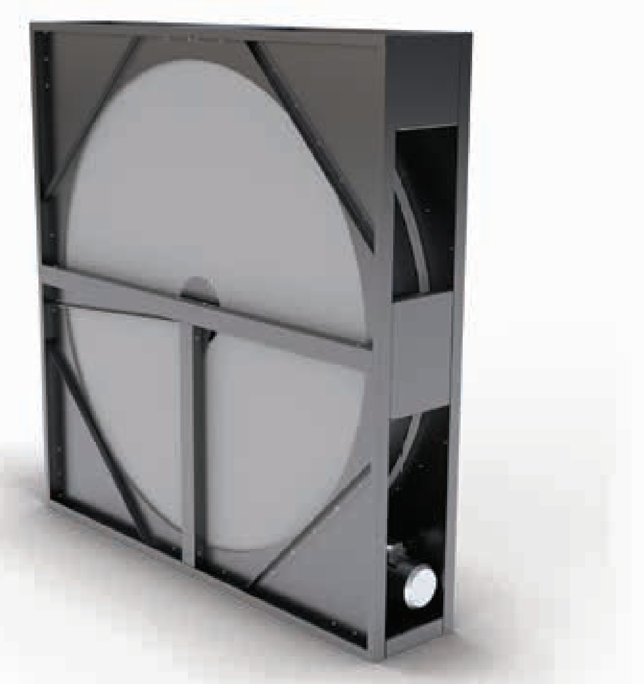


Figure 16: Rotary heat exchanger ©2VV s.r.o.

11.2.2 Condensate drainage

In case of higher indoor humidity during winter season, water condensation inside heat recovery exchanger can occur on its exhaust side. Especially recuperative plate exchangers have a tendency for condensation. The reason is that its plates are colder from outdoor air than the dew point of extracted indoor air. For reliable and easy condensate outlet from the exchanger, its plates should be oriented vertically, and the condensate outlet direction should be the same as the exhaust air direction, downwards if possible. Ideally, the heat exchanger should be oriented inside the unit sloped in the direction of the condensate outlet. Unit should have an internal watertight condensation pan sloped from all sides into a water outlet placed on bottom of the unit, allowing easy and quick condensate outlet. It is very important to secure reliable condensate drainage from the unit to the sewage system. To do so, the unit condensate outlet must have its own siphon ideally with a ball. Such a solution secures non-problematic and maintenance-free condensate drainage, avoiding blockage by counter airflow if there is underpressure inside the unit.

If the condensate drainage path downwards is problematic, the solution could be to use an external condensate pump such as those used in air conditioning systems.

PART 3:
RESIDENTIAL VENTILATION UNITS WITH HEAT RECOVERY

11.2.3 Sensibility of freezing

If the outdoor air temperature is below 0°C there is threat of condensate freezing inside heat recovery exchanger blocking the exhaust air channel and cancelling balanced ventilation and heat recovery.

The outdoor temperature freezing limit (threshold) is mainly dependent on indoor relative humidity (higher humidity = higher freezing limit) and exchanger thermal efficiency (higher efficiency = higher freezing limit).

Indicative freezing limits for plate exchangers and rotary wheel exchangers depending on the outdoor temperature and indoor humidity are illustrated in Figure 17. The presented limits correspond to typical temperature efficiency values (85% for plate exchangers and 75% for rotary exchangers).

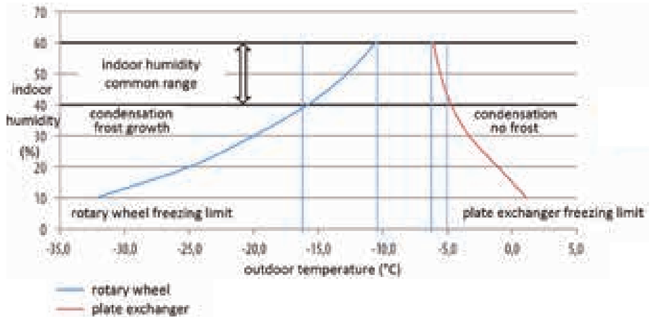


Figure 17: Indicative freezing limit for plate and rotary exchangers ©2VV s.r.o.

The freezing of recuperative plate heat exchangers starts at significantly higher outdoor temperature (approx. -5°C) compared to regenerative rotary wheels (approx. -15°C). Frozen regenerative wheels can be permanently damaged.

The freezing limit can be significantly lowered by using an enthalpic plate heat exchanger with moisture (humidity) recovery.

11.2.4 Defrosting strategy

The aim of defrosting measures is to keep balanced ventilation with heat recovery running with no influence on indoor comfort even at extreme winter outdoor air conditions, and to protect the exchanger against damage. Below follow some examples of different defrosting strategies:

a) Outdoor air pre-heater (mostly electric ideally with modulated power control / brine / earth) - reliable solution keeping heat exchanger just above freezing limit and keeping balanced ventilation unchanged with minimum energy consumption, ideally combined with heat recovery exchanger pressure sensor or exhaust air humidity sensor

b) Heat recovery by-pass / lowering wheel rotation speed – decreasing thermal efficiency and supply air temperature (lower indoor comfort), balanced ventilation, additional post-heater is needed otherwise there is discomfort cold supply air during defrosting period

c) Under-pressure ventilation (lowering, shut-off supply / increasing exhaust airflow) – unbalanced ventilation, possible cold draughts at windows/doors, bad ventilation rate during defrosting period

d) Recirculation of exhaust airflow to supply airflow via heat exchanger – no ventilation during defrosting period (recirculation instead of ventilation)

e) Sectional defrosting (flap changes one part of heat exchanger recovering / second defrosting)

11.2.5 Moisture recovery – Impact on IEQ and freezing

Beside heat recovery during wintertime, it is advantageous to also have moisture recovery because outdoor air in winter has a low absolute humidity and therefore ventilation decreases indoor relative humidity below hygienic limit (approx. 30%). Especially residential buildings with low internal humidity sources suffer from dry unpleasant indoor air. Dry air causes discomfort and lengthens the viable lifetime of bacteria and viruses in the air, resulting in higher infection risks. Moisture recovery can be performed by using a rotary wheel exchanger ideally with a sorption layer or using a so-called enthalpic plate exchanger (recovering sensible energy and latent energy in water vapour). Because moisture is transferred from extract air into supply air, there is no or minimum risk of condensate freezing inside exchangers with moisture recovery.

11.2.6 Internal leakages

Internal leakages result in a fraction of extract air (containing odours and pollutants from wet rooms) being recirculated into the supply air and distributed into the habitable rooms (living room and bedrooms). It deteriorates Indoor Air Quality. Moreover, internal leakages distort the measured heat recovery temperature efficiency, which has to be corrected to the real value. Internal leakages are caused by small openings partly inside the heat exchanger and partly inside the ventilation unit structure such as walls and sealings.

Generally, recuperative plate heat recovery exchangers have significantly lower internal leakages than regenerative rotary wheels. In rotors, the amount of leakage is strongly dependent on the pressure differences between the extract and supply air. These differences are mainly influenced by the fan positions relative to the exchanger, and connected duct system pressure losses. The recommended fan configuration is both fans downstream or both fans upstream of the heat recovery exchanger.

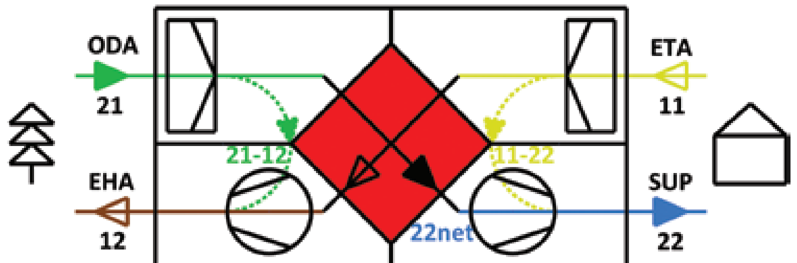


Figure 18: Internal leakage in residential ventilation unit ©2VV s.r.o.

There are two methods for rating internal leakages of a whole bidirectional residential ventilation unit according to EN 13141-7: the pressure method and the tracer gas method. The leakage rate is given as the ratio between internal leakage airflow and reference airflow. The pressure method is used for the classification of recuperative plate heat exchangers and the tracer gas method for the classification of regenerative rotary wheels. Unfortunately, these two methods are not mutually comparable because of different pressure conditions. The classification goes from the best (A1, B1, or C1) to the worst (A3, B3, or C3) as presented in Table 5.

Table 5: Internal leakage classification by EN 13141-7

Recuperative HRS		Regenerative HRS			
Pressure test		Tracer gas test			
		In chamber		In duct	
Class	At 100 Pa	Class	Rs, tot	Class	RS, Int
A1	≤ 3 %	B1	≤ 1 %	C1	≤ 0,5 %
A2	≤ 7 %	B2	≤ 2 %	C2	≤ 2 %
A3	≤ 14 %	B3	≤ 6 %	C3	≤ 4 %
Not classified	> 14 %	Not classified	> 6 %	Not classified	> 4 %

11.2.7 Thermal by-pass

All Residential Ventilation Units placed on the EU market must be equipped with a thermal by-pass facility. The thermal by-pass is particularly important in warm climates in buildings without air conditioning. The task of the thermal by-pass is to disable heat recovery when it is not needed and to enable so called free cooling in summer (supply of outdoor air when it is colder than indoor air). Depending on the exchanger type, the thermal by-pass function can be performed in different ways. For rotary heat exchangers it is enough to stop the wheel. In case of plate exchangers, a physical air by-pass is necessary. The by-pass and heat recovery exchanger should be equipped with dampers. Ideally both counter-opening dampers should be modulated 0-100% open/shut position. It is important that the by-pass damper in closed position should be airtight to avoid unwanted deterioration of heat recovery efficiency. The by-pass channel should be well dimensioned (approx. min. 20% of heat recovery exchanger inlet area) to allow at least the same airflow as in case of airflow through the heat recovery exchanger with fully closed by-pass. The by-pass channel should be thermally insulated to avoid unwanted condensation on the exhaust side. By-pass usage for defrosting of heat recovery exchanger in winter is not an ideal solution.

©J. Pichler GmbH


©J. Pichler GmbH

11.3 FAN

The fan is also a key component of the residential ventilation unit, as it is responsible for the movement of the air. Fans have a major impact on the energy consumption and acoustic performance of the unit.

Regulation (EU) 327/2011 on Ecodesign requirements for fans sets out EU-wide minimum requirements for the efficiency of fans with electric power input ≥ 125 W. This regulation is currently under review, and new increased requirements are expected to come into force soon.

For fans installed in residential ventilation units, the efficiency requirements should follow the level of centrifugal backward curved fans (not forward curved) and the actual efficiency should be several percent higher than the minimum requirements.

Ventilation units themselves are subject to Ecodesign requirements as well, stipulated in Regulation (EU) 1253/2014 (see also chapter 12). This regulation requires that the fans in residential ventilation units should be equipped with a multi-speed or variable speed drive. Variable speed drives allow stepless adjustment of the fan operating point in response to demand. They enable further energy savings and are therefore recommended over multi-speed drives. It is also important that the fans effectively communicate and exchange data with the controller (e.g. via bus communication) to optimise the operation.

As mentioned in previous chapters, fans are one of the main sources of noise in ventilation systems. Thus, it is crucial that the fans mounted in a ventilation unit feature low sound power level, both on the inlet and outlet.

The way the fan in is assembled in the unit matters. Improper installation leads to so called 'system loses' which result in the deterioration of overall fan performance, both in terms of energy efficiency and acoustics. Correct installation requires consideration of the distances between fan inlet and outlet, air velocity, and obstacles in the airstream, among other aspects.

11.4 CONTROL SYSTEM

The controller of a residential ventilation unit is like the brain of the system. All the coordination necessary to manage the various components of the ventilation system is done by the controller. The controller analyses the parameters returned by the sensors (temperature, humidity, CO_2, VOC, etc.) and the feedback from the components. Based on this information, it defines which functions to apply to the systems and then sends control signals back to system equipment, such as motors, dampers, and other components.

The controller is also equipped with communications buses. Communication via Modbus enables the exchange of more information between the different components of the ventilation system and the controller. Among other things, Modbus communication can refine the regulation functions and translate more information to the end user such as the energy consumption of a fan.

11.4.1 Demand Control Ventilation (DCV)

As discussed at length in previous chapters, it is essential to ensure that the air inside a dwelling is of good quality. To this end, the right volume of air must be supplied by the ventilation system, in order to ensure sufficient air renewal. If there is insufficient air renewal, the Indoor Air Quality will suffer as a result.

However, it is possible to ventilate 'too much', which is inefficient. This occurs when energy is spent ventilating more than strictly necessary to achieve the desired level of air quality, or when there are no occupants to benefit from the clean air.

A good control system enables the ventilation system to adjust to precisely the right level. It takes into account the use patterns of the end user to determine the necessary amount of air to ensure optimal Indoor Air Quality. To do this, the controller takes into account various parameters such as:

- The concentration of CO_2, which correlates with the number of people in the room
- The moisture level, which is a good indicator of the need for air renewal in the kitchen and bathroom
- The concentration of VOC and fine particles, which are usually caused either by human activities (cooking, cleaning, etc.), released by materials (carpets, paint, etc.), or sourced from outside
- The activation of a presence detector, which is a good indicator for toilets notably

To be as accurate as possible in measuring these parameters, the sensors should be installed in the room according to the manufacturers' recommendations.

Communication between the controller and room sensors can be wired or wireless.

11.4.2 Zone control

The control system is also able to ensure that each zone is adequately supplied. There are several strategies to regulate zones. Either the zone is regulated according to the supplied airflow or the regulation is done according to a fixed pressure within the ventilation ductwork. In either case, the controller receives a direct or indirect pressure signal to control the fans most effectively.

11.4.3 Interaction with other appliances

In the case of a building with several appliances, a building management system (BMS) may be used. This has the advantage of grouping, on a single interface, the status and main parameters of all the appliances connected to it. It is possible to view alarms and setpoints, and control certain parameters. It also allows to schedule, trend, create reports, and visualise consumption.

To be integrated into a BMS, it is important that the controller can communicate via BACnet, which is the most common communication bus. Other communication buses such as Modbus and LON also allow connection to certain types of BMS.

11.4.4 Controller display

Many types of displays exist on the market. They can be with or without a screen, touch or not, wired or wireless, but they all have the same function: to help the user to communicate and understand the operation of the ventilation system. Among the main functions on the display are:

- Changing the ventilation mode
- Setting a weekly calendar
- Receiving information on the status of the ventilation system (e.g. a reading of alarms)

11.4.5 Mobile apps – Internet access

In addition to or in replacement of a display, it is possible to communicate with the controller remotely. A direct connection can be made either wired directly to the controller, or with a wireless connection via a LAN type Wi-Fi for example.

An indirect connection implies that the controller is connected to the internet through a SIM card or an internet router. This has the advantage of making the ventilation system available 24/7. In the latter case, the data of the ventilation system is usually stored in the cloud. A cloud access offers many possibilities:

- Access to real-time data
- View previous data
- Compare several ventilation systems
- Be alerted to status changes (i.e. alarm)
- Control
- Update software and firmware
- Analyse data for early detection of failures
- Save files related to the ventilation system

It is important to note that any type of wireless connection or internet connection carries risks, including the risk of the system being hacked. Total protection cannot be guaranteed, but there are security standards and certifications that can help mitigate these risks.

11.4.6 Data logging, energy consumption meter

For some installations, it may be interesting to measure the energy consumption of the different airflows as well as the heater and cooling sections of the larger air handling units. These measuring devices can be connected via different types of communication such as the M-Bus, specific for this function.

11.5 CASING

The casing of residential ventilation units is important for its performance and maintenance. Its main features are outlined in the following chapters.

11.5.1 Construction and material of the cabinet

Construction and insulation material are important because insufficient insulation can decrease thermal efficiency or bring condensation on parts of the unit. They also have a significant impact on sound insulation. Typical casing designs are described below.

Sheet metal casing with thermal insulation: Metal parts are insulated by mineral wool or foams. All components (i.e. fans, heat exchanger, by-pass damper) are installed on the metal parts. The insulation thickness should be 25 mm or more. This is one of the most popular solutions. The main disadvantage of this solution is high weight.

Sheet metal casing with EPS, XPS or EPP: A similar solution as above but the insulation material is different. EPS (expanded polystyrene) or EPP (expanded polypropylene) can be used as a construction material and components can be installed directly on them. With this type of construction, the weight of the unit can be much lower.

EPP casing: EPP can be used as a construction material where all components are installed directly to the EPP. This material has good mechanical strength and impact absorption combined with a very light weight. It is not as fragile as EPS which reduces the risk of damage during maintenance. With this solution weight can be reduced by as much as 50% compared to the more conventional solution of metal sheets with insulation. However, this design usually features lower sound insulation.

11.5.2 Air tightness

Besides weight, air tightness is another important parameter that depends on the casing design and materials. Good units reach class A1, B1, or C1 (different letters for different types of heat exchanger) according to EN 13141-7. Air tightness is relevant for both internal leakage (between airflows) and external leakage (through the casing), both of which affect the efficiency of the unit. To reach the best class in leakage classification, all construction parts should be sealed with special glues or other sealing materials. Removable parts (like the heat exchanger or filters) should also be installed with sealing materials (special foams or rubber sealing).

11.5.3 Easy access to filters and heat exchanger

Easy access to filters and the heat exchanger is very important to facilitate maintenance. Filters should be regularly replaced (see chapter 11.1). The heat exchanger should be cleaned every two years.

In most modern units, filters are accessible through special covers in the casing. It should be possible to replace filters without any tools in few minutes. To take the heat exchanger out in a typical unit, it is necessary to open or uninstall the front cover. Usually, it takes 10-20 minutes and only basic tools are needed.

Figure 19: Easy access to filters ©Alnor Sp. z o.o.

12. RELATED REGULATIONS, STANDARDS AND CERTIFICATION

12.1 DIRECTIVES AND REGULATIONS

Residential ventilation units fall under the European Ecodesign Directive (ErP - Energy Related Products) that lays down general requirement for products consuming energy. The specific Ecodesign requirements for Residential Ventilation Units are defined in Regulation (EU) 1253/2014. All ventilation units placed on the EU market must comply with the minimum requirements stipulated in this regulation. A sister Regulation (EU) 1253/2014) defines the requirements for energy labelling of residential ventilation units. The energy labelling measures support the Ecodesign measures by showing in a simple manner (energy class label) the actual energy performance of a product to the end user. In this way, the end user, who typically does not have any expertise related to the product, can make an informed decision in choosing the most efficient product.

The main Ecodesign requirements for residential ventilation units are a maximum value of the unit's Specific Energy Consumption (SEC) factor, and the requirement to have a multi-speed or variable speed drive for the fans, a thermal by-pass facility, and visual filter change warning signal.

12.1.1 Specific Energy Consumption factor

Specific Energy Consumption (SEC) expressed in kWh/(m²a) is a coefficient showing the annual consumption of energy for ventilation per square meter of heated floor area in a dwelling or building. SEC uses the energy consumption of a natural ventilation system as a base reference, which is to say that the metric expresses how much energy the mechanical ventilation system saves compared to a natural ventilation system. The lower the SEC value, the more efficient the system is.

At the time of writing, the legal requirement is for the SEC value of a unit (calculated for average climate) to be no more than 20 kWh/(m²a).

The calculation method of SEC is complex. It takes into consideration not only the energy consumed by fans or the efficiency of heat recovery (including energy for defrosting) but also the way in which the ventilation is controlled (e.g. a small bonus if controlled only with a timer, a bigger bonus if controlled with air quality sensors).

12.1.2 Energy label

The SEC value also determines the energy class that will be displayed on the energy label. The energy label is mandatory for residential ventilation units. The classes are defined as ranges of SEC values, going from A+ to G. A+ is best class and denotes a more efficient unit. G is the worst class and denotes a less efficient unit. The best units available on the market today are in class A+. Even some of the worst heat recovery residential ventilation units on the market can still achieve a C in the current rating. The same energy labelling scheme also applies to exhaust ventilation system without heat recovery. These usually reach class D at best.

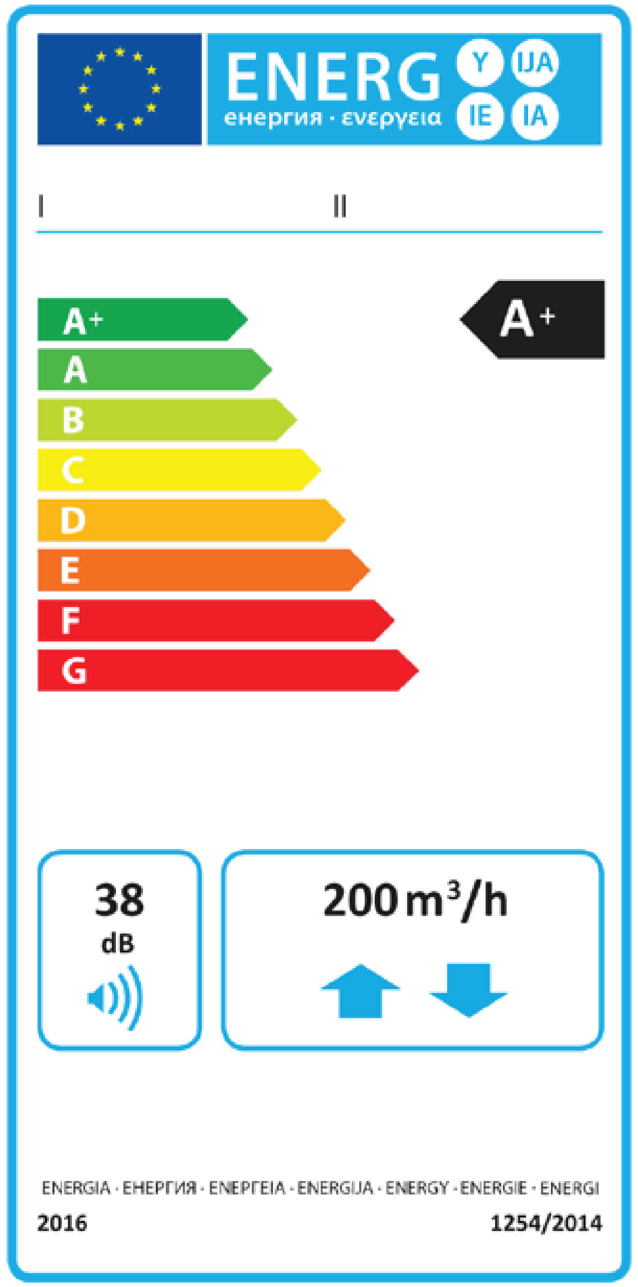


Figure 20: Energy label for RVU

12.1.3 Information requirements

Besides minimum requirements for the energy performance, the Ecodesign Regulation also requires for certain product information to be provided in the technical documentation. This information must also be freely accessible on the website of the manufacturer (or their authorised representative or importer). There are 21 pieces of information that must be provided, including:

- SEC value and SEC class
- Type of heat recovery
- Thermal efficiency of heat recovery
- Sound power level
- Type of controls
- Maximum and reference airflow rate
- Internal and external leakage rates

This information allows the performance data to be easily verified.

Both regulations are under review at the time of writing. The revised regulations are expected to be adopted in 2022 and come into force in 2023. The new requirements tend to be more system focused.

12.2 RELATED EN STANDARDS

To ensure that the performance of each heat recovery residential ventilation unit is declared in the same manner, all tests and ratings must be carried out in accordance with related EN standards. For ducted residential ventilation units with heat recovery the following main standards apply:

- EN 13141-7 – Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 7: Performance testing of ducted mechanical supply and exhaust ventilation units (including heat recovery)
- EN 13142 – Ventilation for buildings – Components/products for residential ventilation – Required and optional performance characteristics

The former standard provides complete procedures for the performance data testing and rating, while the latter defines the relationship between the EN standard and essential requirements of Regulation (EU) 1254/2014.

The tests should be performed in accredited laboratories and the outcomes presented in the technical documentation of the product. Upon the customer's request, the manufacturer should provide test reports.

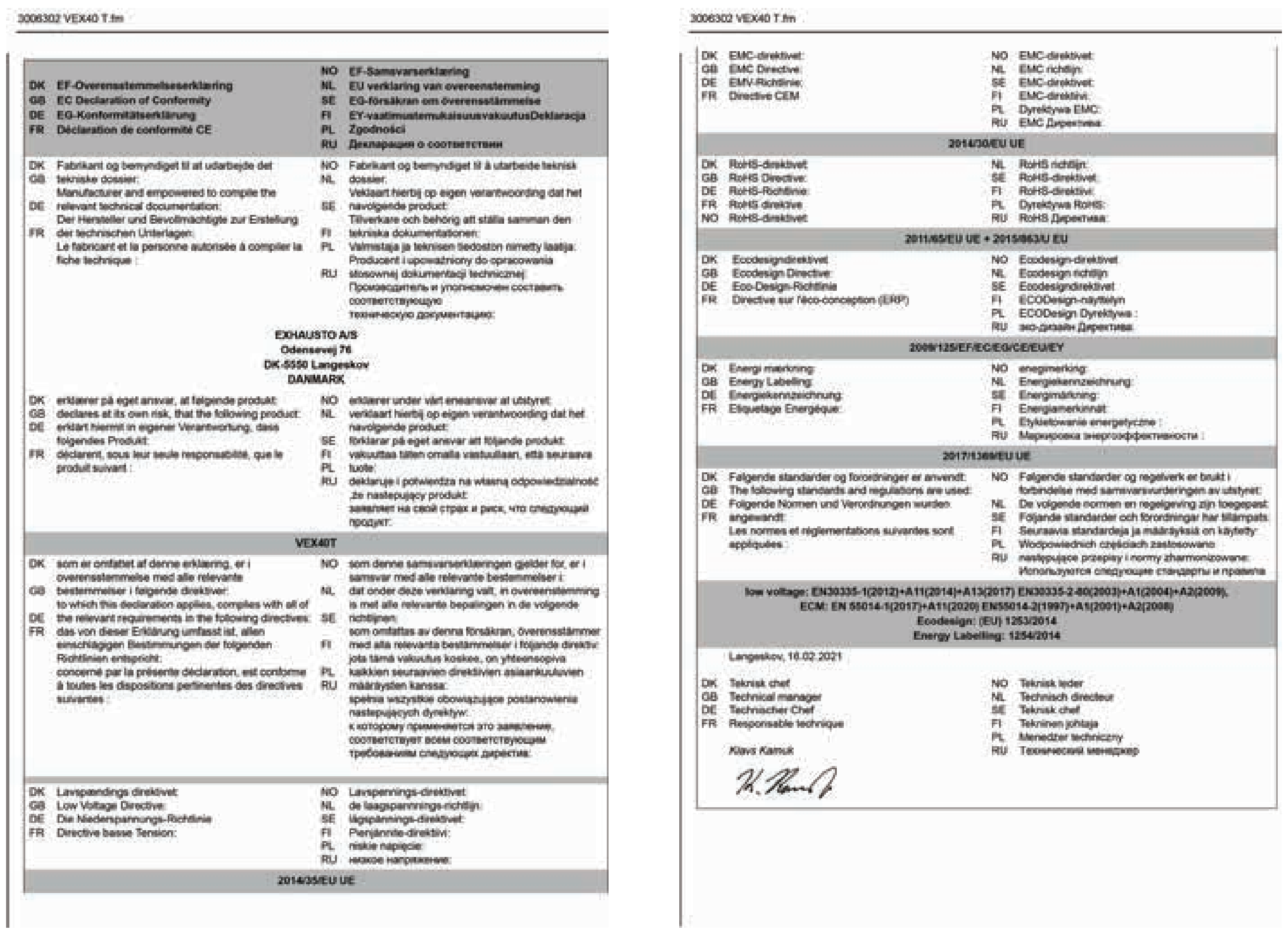
12.3 REQUIRED MANUFACTURER DECLARATION (CE)

Each ventilation unit placed on the EU market must be CE marked and delivered with a manufacturer's or distributor's EU declaration of conformity. The declaration indicates that the product complies with all relevant requirements of the European product safety directives. The EU declaration must contain information such as the name and address of the manufacturer or authorised distributor, a description of the product and model, reference to the directives that apply to the product, a list of standards used, the name and position of the authorised person in charge, a signature and the date. For residential ventilation units, relevant EU directives include:

- Machinery Directive 2006/42/EC
- EMC Directive 2014/30/EU
- Ecodesign Directive 2009/125/EF

An example of the EU declaration of conformity is presented in Figure 22.

Figure 21: CE mark



3006302 VEX40 T.fm

GB EC Declaration of Conformity

GB Manufacturer and empowered to compile the relevant technical documentation:

EXHAUSTO A/S
Odensevej 76
DK-5550 Langeskov
DANMARK

GB declares at its own risk, that the following product:

VEX40T

GB to which this declaration applies, complies with all of the relevant requirements in the following directives:

GB Low Voltage Directive:

2014/35/EU UE

3006302 VEX40 T.fm

GB EMC Directive:

2014/30/EU UE

GB RoHS Directive:

2011/65/EU UE + 2015/863/U EU

GB Ecodesign Directive:

2009/125/EF/EC/EG/CE/EU/EY

GB Energy Labelling:

2017/1369/EU UE

GB The following standards and regulations are used:

low voltage: EN30335-1(2012)+A11(2014)+A13(2017) EN30335-2-80(2003)+A1(2004)+A2(2009),
ECM: EN 55014-1(2017)+A11(2020) EN55014-2(1997)+A1(2001)+A2(2008)
Ecodesign: (EU) 1253/2014
Energy Labelling: 1254/2014

Langeskov, 16.02.2021

GB Technical manager

Klavs Kamuk

Figure 22: Example of an EC declaration of conformity ©Exhausto A/S

12.4 RELIABILITY OF DECLARED PERFORMANCE DATA – THIRD PARTY CERTIFICATION

Under the current EU conformity assessment system, residential ventilation units belong to a group of products for which declaration of conformity can be issued based on self-assessment. This means that the manufacturer (or distributor) itself declares all performance data and compliance with relevant EU regulations. This assessment process is not supervised by any independent external body. Once placed on the EU market, the conformity of a product may be randomly checked by the market surveillance authorities of EU Member States, but only a small number of products are checked every year.

Designers of ventilation systems must meet tight energy performance requirements stipulated in national building codes. Their energy calculations are based on data provided by residential ventilation unit manufacturers. Even slight discrepancies between actual and declared energy performance of the unit can result in significant differences in real energy consumption, and consequently in the energy performance of the building and its running cost. Furthermore, if the actual performance of the product deviates from the declared one, the desired level of indoor environmental quality may not be met. Residential ventilation units are complex devices comprising numerous essential components. Carrying out a reliable performance test of such devices is difficult and costly.

12.4.1 Eurovent Certified Performance

In answer to this problem, there are external certification bodies which take responsibility for the reliability of the declared performance by verifying it independently. The major accredited European third-party certification body for HVACR products is Eurovent Certita Certification, which operates over 40 certification programmes including one for residential ventilation units. All certified units are marked with the globally renowned and recognised 'Eurovent Certified Performance' label. The Eurovent certification programme does not come down to a simple and single performance test. Quite the contrary, it comprises much more, including evaluation of selection software consistency and accuracy, periodic factory audits and periodic performance tests in accredited laboratories.

12.4.2 Other quality labels and marks

Besides the comprehensive Eurovent Certita Certification programme, there are other quality mark schemes for residential ventilation units. Most are national or local in scope and only few involve independent performance tests. Although most are voluntary, they may in practice be required to be competitive in certain markets. The main relevant schemes include:

- Deutsches Institut für Bautechnik (DIBt) National technical approval (abZ) – Mandatory in Germany
- German VDI 6022 hygiene guidelines approval
- German RLT guidelines certificate
- Passive House Institute certificate

Figure 23: Eurovent Certified Performance mark

13. COMMISSIONING

Ventilation units may only be put into operation with new air filters. The work and settings have to be documented in a commissioning log. At least the following activities must be carried out:

- Adjusting the airflow rates and ensuring balanced operation (on a unit and on a dwelling level).
- Measurement of the power consumption of the supply / exhaust device.
- The parameters required for operation can be set on the control system and recorded in the commissioning log. It can be done via an app (if available) or via the HMI of the ventilation system.
- During hand-over, the client must be instructed on the operation of the ventilation system. The documentation, consisting of operating and maintenance instructions and the commissioning protocol, must also be handed over.

14. CONTROL SETTINGS

Most residential ventilation units that are equipped with an automation control board are supplied with standard software configuration. Usually all residential units have 'Plug & Play' functionality in order to eliminate expensive installation work.

The simplest bidirectional residential ventilation units in the EU may have fan speed regulation, temperature measurement, fire protection input, and a filter pollution indicator. Advanced units are equipped with a more intelligent control board and can control not only internal components but also external devices. Therefore, they can be adjusted during the installation according to the users' requirements. But as these units are already preconfigured, the most common task for the installer is entering the time control settings and/or adjusting the airflows.

Time control is usually done via a weekly calendar, where fan speed settings and temperature setpoints are regulated according to the users' daily schedule. In most cases, ventilation and temperature setpoints are decreased during the daytime on working days. It allows savings on electricity costs on ventilation, and most importantly on electric air heating.

Usually, units have standard **operation modes** configured with adjusted fan speed and supplied air temperature. Installers can change the speed of both fans separately and adjust supplied air temperature according to the required parameters. It might be that other extended parameters can be defined during the commissioning.

Despite the unit's 'Plug & Play' functionality, external components can be connected to residential heat recovery units, which may require additional configuration.

- **External electrical heater:** The air temperature after the heat recovery exchanger can be between 12°C and 18°C. To provide a comfortable climate, the air can be heated to the required temperature. Some units have integrated heaters, but for others an external duct heater is required. An electric heater can be autonomous, but such devices cost much more than those which can be controlled from the ventilation unit. The external heater can be controlled by on-off or 0-10V signals. 0-10V control gives more fluent and precise heater control, which saves energy. In average and cold climate zones, the heater consumes 3-4 times more energy than EC fans, therefore 0-10V electrical heater control is important for higher annual energy savings.
- **External water heater/cooler**: A water heater is not common in residential ventilation, due to high installation costs. Therefore, most water heaters are external ones. The frost protection of the water heater is activated when the water heater temperature drops below 5°C. This water goes back into the water supply network. In a more advanced bidirectional residential ventilation unit, installers or function logic of the controller can set up automatic switching from heating to cooling, and vice versa, according to the season.
- **External preheater:** Also, part of heat exchanger frost protection settings. As the plate heat exchanger can freeze in sub-zero outdoor air temperatures, frost protection is usually implemented in the control settings. The most common is the preheater. As quite a lot of counterflow units come without an integrated pre-heater, an external pre-heater can be connected to the unit and configured accordingly. The installer can also adjust the standard frost protection features, by either activating the airflow misbalance, or defrosting by using the by-pass damper.
- **External air dampers:** The control board of a unit can control the actuators of the external air dampers. The actuators need to be connected and configured if required.
- **Indoor Air Quality sensors:** Sensors for relative humidity, CO_2, and VOC can be connected for demand-controlled ventilation. The installer may adjust the required setpoints.
- **Presence detectors and external switches:** The installer can connect presence detectors to control ventilation and save energy. Various other switches can also be used for ventilation control in order to turn it on or off, and to increase or decrease the air supply. One of the most common examples is the fireplace function, which increases the supply fan speed to provide overpressure for safe fireplace operation
- **Connection to the fire protection system:** Safety requirements differ in various countries, but in case of fire the ventilation unit is required to take actions according to the fire alarm signal. Therefore, a heat recovery unit can be switched off, the air supply increased, or the air extraction increased, according to local legal requirements. The installer can adjust the settings according to legal requirements. In some cases, there is a requirement for fire dampers to be controlled by the ventilation unit, therefore fire dampers can be connected to the unit.
- **Settings for filter pollution monitoring:** Can be changed according to user requirements. Usually, in residential units, filter pollution is monitored by a switch or a timer. If not included in the standard configuration, additional air pressure relays can be connected to control pollution by pressure.

15. TRAINING FOR THE USER AND MAINTENANCE CONTRACT

Proper unit maintenance increases service life and reduces energy costs. As most residential units are equipped with long service life EC fans, a properly maintained unit may last for more than 10 years.

The installer should train the end user to carry out the following simple maintenance and operations:

- Modification of the time control settings
- Changing the ventilation mode, increase or decrease air supply, and change the temperature manually
- Turning on/off specific ventilation modes, such as, for example, night cooling
- Filter change and resetting the timer

As with most household electrical appliances, the other main maintenance tasks require technical knowledge, and it is recommended they are only performed by qualified personnel. The unit requires periodic cleaning and inspection: not less than twice a year, and it is recommended that it is carried out before winter and summer. The main service tasks include:

- To change the filters
- To clean and disinfect the unit
- To inspect the fans and clean the impellers
- To clean the heat exchanger
- To clean the heater and pre-heater
- To check and replace the rotor belt if needed
- To check and replace the rotor insulation if it is worn
- To check the operation log for errors

The maintenance must be carried out according to a unit manufacturer's instructions.

ANNEX I

ANNEX I - DESIGN AIRFLOW RATES IN MODEL APARTMENTS

In small apartments, it is typically the extract airflow that defines the total airflow rate, and the supply airflow has to be increased accordingly. In large apartments with many bedrooms, the total supply airflow rate is typically higher, and the extract airflow rates are increased to balance the ventilation. The average airflow rate of the whole residence may determine the total airflow rate in the case of very large rooms. This can occur, for example, in large, detached houses.

The determination of airflow rates is shown in the following two examples. Table 6 provides a sizing procedure in a three-bedroom apartment and Table 7 for a one-bedroom apartment. The plans and design airflow rates are shown in Figure 24.

Table 6: Airflow rate calculation in three-bedroom apartment (the determining airflow rate is marked bold)

Room	Area, m^2	Airflow rate, l/s (m³/h)		
		Supply	Extract	General air change
1.1 Kitchen	11,3	-	8 (28,8)	
1.2 Bedroom	11,1	12 (43,2)	-	
1.3 Bedroom	13,4	12 (43,2)	-	
1.4 Bathroom	2,8	-	15 (54,0)	
1.5 WC	1,3	-	10 (36,0)	
1.6 Corridor	14,8	-	-	
1.7 Bedroom	10,9	8 (28,8)	-	
1.8 Living room	13,6	12 (43,2)	-	
Entire apartment	79,3	-	-	79,3 * 0,42 = 33 (118,8)
Total		44 (158,4)	33 (118,8)	33 (118,8)

The extract airflow rates are smaller than the supply and they are to be increased by 11 l/s. In this case this is done by increasing kitchen extract, resulting in design extract airflow rates:

- WC 10 l/s
- Bathroom 15 l/s
- Kitchen 8 + 11 = 19 l/s

This results in design total supply and extract airflow rates 44 l/s. This total airflow rate of 44 l/s corresponds to 0,80 air changes per hour, which is quite high because of many small bedrooms and expected high occupant density in this three-bedroom apartment.

Table 7: Airflow rate calculation in one-bedroom apartment (the determining airflow rate is marked bold)

Room	Area, m^2	Airflow rate, l/s (m³/h)		
		Supply	Extract	General air change
2.1 Room	3,0	-	-	
2.2 Kitchen	9,3	-	8 (28,8)	
2.3 Living room	16,2	12 (43,2)	-	
2.4 Room	3,7	-	-	
2.5 Bathroom	3,5	-	15 (54,0)	
2.6 Bedroom	11,5	12 (43,2)	-	
Entire apartment	47,2	-	-	47,2 * 0,42 = 20 (72,0)
Total		24 (86,4)	23 (82,8)	20 (72,0)

In this one-bedroom apartment, total supply and extract airflow rates are almost equal and one extract airflow rate has been increased by 1 l/s to balance the ventilation. The total design airflow rate of 24 l/s corresponds to 0,73 ACH.

The total design airflow rates calculated in the previous tables do not include the temporary boost from the cooker hood which is in both cases 25 l/s. In three-bedroom apartment, this flow rate may be temporarily 'borrowed' from the other extracts if the cooker hood damper is opened and so a ventilation boost is not necessary. In small one-bedroom apartment boosting the ventilation and borrowing from other extracts is a reasonable solution to achieve 25 l/s cooker hood airflow.

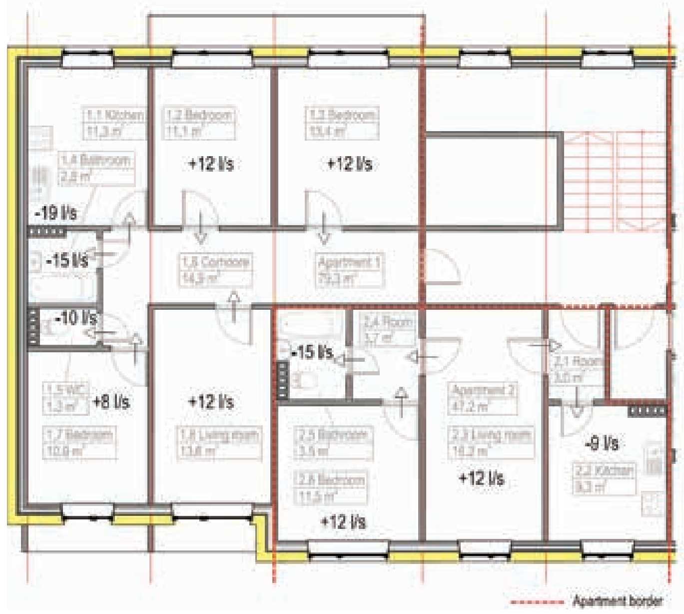


Figure 24: Airflow rates and transfer air paths in three- and one-bedroom apartments ©REHVA

An example of selecting airflow rates for a larger detached house is shown in Table 8 and Figure 25. In this house, transfer air from bedrooms flows through the living room to the kitchen and hallway. The living room supply airflow rate (calculated with the formula in Table 7) results in 19 l/s, but due to the transfer air it is reduced to the minimum value of 12 l/s. When transfer airflows induced by kitchen and hallway extracts are included the total airflow to the living room is 12 + 15 = 27 l/s which is higher than the required 19 l/s. Minimum supply airflow rates of 8 l/s are used for 3rd and 4th bedrooms (or office). The hobby room, which is not continuously occupied, is sized according to an average airflow rate of 0,42 l/(s·m^2) resulting in 11 l/s for supply and extract. The total supply airflow rate of 71 l/s is higher than the total extract flow rate, therefore the extract airflow rate in the kitchen is increased to 19 l/s. During cooker hood operation this value needs to be boosted to 30 l/s. In this case, an average airflow rate of the whole residence of 0,42 l/(s·m^2) gives an airflow rate of 68 l/s which is very close to the determined airflow rate of 71 l/s, that corresponds to the air change rate of 0,58 ACH with an average room height of 2,7 m.

Table 8: Airflow rate calculation in five-bedroom house (the determining airflow rate is marked bold)

Room	Area, m^2	Airflow rate, l/s (m^3/h)		
		Supply	Extract	General air change
1.1 Living room	42,1	12	–	
1.2 Bedroom	19,7	14	-	
1.3 Bedroom	14,9	12	-	
1.4 Bedroom	12,5	8	-	
1.5 Room	13,2	8	-	
1.6 Sauna	3,1	6	-	
1.7 Hobby room	25,9	11	11	
1.8 Kitchen	6,6	-	19	
1.9 Hallway	4,3	-	8	
1.10 WC	2,0	-	10	
1.11 Utility room	4,0	-	8	
1.12 Bathroom	6,6	-	15	
1.13 Corridor	8,2	-	-	
Entire apartment	163,1	-	-	163,1 * 0,42 = 68
Total		71	71	68

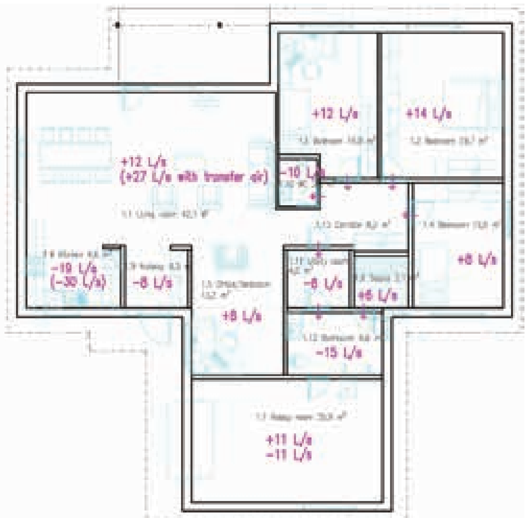


Figure 25: Airflow rates and transfer air paths in a detached four-bedroom house ©REHVA

ANNEX II – INDICATIVE SELECTION OF SOUND ATTENUATOR BASED ON 125 HZ FREQUENCY

A simplified method proposed in the REHVA Residential Heat Recovery Ventilation Guidebook provides for an indicative selection of a silencer with consideration of the critical frequency 125 Hz. The selection can be made based on Figure 26, which shows sound pressure in a sample room depending on ventilation unit sound power at the frequency of 125 Hz and the type and length of sound attenuator. For example, if a ventilation unit has a sound power 51 dB(A) in the supply connection and the room sound pressure limit is 25 dB(A), then a circular sound attenuator with internal and external diameters 125 and 225 mm with length at least 900 mm should be used as an initial choice. A rectangular sound attenuator with length 1000 mm could be used as an alternative. Shorter sound attenuators probably would result in the room sound pressure exceeding the limit value. This figure is valid for units with the critical frequency of 125 Hz.

Increasing the length of attenuators has a more significant impact on higher frequencies. Lower frequencies can be effectively attenuated by using two short attenuators instead of one long one. This figure is only suitable for initial selection of attenuators and the detailed sound calculation cannot be avoided.

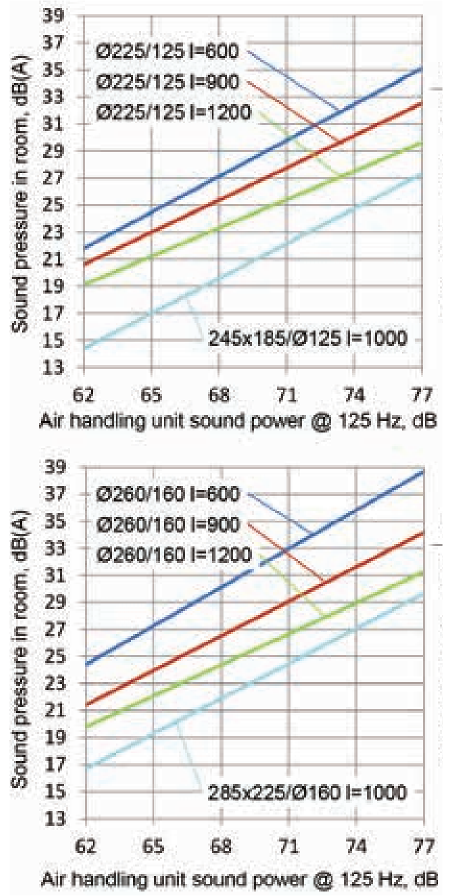


Figure 26: Rough selection of sound attenuator based on the sound power of selected air handling units at a frequency of 125 Hz ©REHVA

ABOUT EUROVENT

Eurovent is Europe's Industry Association for Indoor Climate (HVAC), Process Cooling, and Food Cold Chain Technologies. Its members from throughout Europe represent more than 1.000 organisations, the majority small and medium-sized manufacturers. Based on objective and verifiable data, these account for a combined annual turnover of more than 30bn EUR, employing around 150.000 people within the association's geographic area. This makes Eurovent one of the largest cross-regional industry committees of its kind. The organisation's activities are based on highly valued democratic decision-making principles, ensuring a level playing field for the entire industry independent from organisation sizes or membership fees.

EUROVENT
EUROPEAN INDUSTRY ASSOCIATION

OUR MEMBERS

Our Member Associations are major national sector associations from Europe that represent manufacturers in the area of Indoor Climate (HVAC), Process Cooling, Food Cold Chain, and Industrial Ventilation technologies.

The more than 1.000 manufacturers within our network (Eurovent 'Affiliated Manufacturers' and 'Corresponding Members') are represented in Eurovent activities in a democratic and transparent manner.

For in-depth information and a list of all our members, visit www.eurovent.eu

PRODUCT GROUP PARTICIPANTS

The following organisations actively participate in the Eurovent Product Group 'Residential Air Handling Units' (PG-RAHU):

2VV, AERMEC, AGORIA, aldes, alnor, ASSOCLIMA, Airria
Binnenklimaat Nederland, BRINK, Carrier, CLIVET, DAIKIN, ebmpapst, EFRIARC
enervent, euroclima, EXHAUSTO, FläktGroup, FLEXIT, FLOWAIR, Frapol
HEATEX, Hoval, PICHLER, Keyter, Klimor, komfovent, MANN+HUMMEL
menerga, MITSUBISHI ELECTRIC, nedair, ÖSTBERG, RHOSS, SABIANA, SALDA
SIEMENS, Svensk Ventilation, Swegon, systemair, TALTEKA, TROX TECHNIK, UL
Uniclima, ÜNTES, VALLOX, VBW, VDMA, VELTEK Ventilation, WOLF

Special thanks to REHVA for their significant contribution to this Guidebook.

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

EUROVENT
EUROPEAN INDUSTRY ASSOCIATION

BECOME A MEMBER
Apply now for membership
apply.eurovent.eu

FOLLOW US ON LINKEDIN
Receive most up-to-date information on Eurovent and our industry.
linkedin.eurovent.eu

ADDRESS
80 Bd A. Reyers Ln
1030 Brussels, Belgium

PHONE
+32 466 90 04 01

EMAIL
secretariat@eurovent.eu

www.eurovent.eu

IAQmatters
Yes to a better Indoor Air Quality

For more information, visit
www.IAQmatters.org