VENTILATION

# Engineering and installation

## Basic ventilation principles

STIEBEL ELTRON

# Engineering and installation



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**Specification**

Dimensions in the diagrams are in millimetres unless stated otherwise. Pressure figures may be stated in pascals (MPa, hPa, kPa) or in bars (bar, mbar). The details of threaded connections are given in accordance with ISO 228. Fuse types and sizes are stated in accordance with VDE. Output data applies to new appliances with clean heat exchangers.

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# Our motivation for ventilation

**General information about ventilation**

When people breathe, cook and shower, they release carbon dioxide, odours, heat and water vapour into the indoor air. Up to 8 kg of water per day is released into the indoor air by an average family of three.

Replacement of indoor air with fresh outdoor air is required in order to maintain indoor air quality, as well as to ensure the extraction of humidity. Window ventilation is no longer ecologically or economically sound.

Only a controlled ventilation system can noticeably decrease the ventilation demand without the risk of humidity damage.

There are therefore two critical reasons to ventilate buildings:

» Health protection

» Building protection

**Manual ventilation**

In many older buildings, humidity is reduced through non-airtight window and door frames or through ventilation by means of opening windows. This air change is described as "natural infiltration".

This form of ventilation is no longer ecologically or economically sound.

**Fan-assisted ventilation**

In modern new builds, natural infiltration is not sufficient to expel the humidity.

Even in buildings that have been modernised extensively or with a view to improved energy efficiency, usually insufficient natural infiltration is retained. Windows and doors have an airtight seal, preventing any air change.

In airtight buildings, fan-assisted ventilation systems ensure continuous air change.

Aside from building protection, ventilation systems also ensure a consistently high air quality.

Using appropriate filters, ventilation systems can protect against dust particles, pollen and other pollutants.

Ventilation systems also provide additional sound insulation, as windows and doors remain closed all day.

Ventilation systems replace manual ventilation and are ecologically and economically sound.

**Areas of application for ventilation systems**

Fan-assisted ventilation systems are used in the following types of buildings:

» New build residential buildings

» Existing buildings that have been modernised to optimise energy efficiency, e.g. with airtight windows and doors

» Modernised or partially modernised older residential buildings with airtight windows and retrofitted thermal insulation

» Non-residential buildings, e.g. warehouses or garages

» Buildings with high occupancy, e.g. office buildings, co-working spaces or meeting rooms

» Nurseries and schools

#### New build residential buildings

New builds are thermally well insulated and therefore also airtight. The use of controlled fan-assisted ventilation system is essential for both structural and energy efficiency reasons.

#### Modernised or partially modernised older residential buildings

Modernisation or partial modernisation - installing new windows for example - inhibits the previous natural infiltration, meaning that natural air change no longer occurs. Building damage, for example through mould or fungus on cold bridges, and health problems may occur.

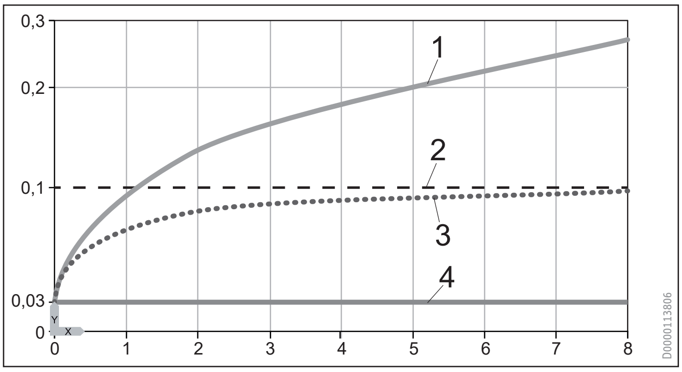
#### Non-residential buildings, e.g. warehouses or garages

In warehouses and garages, excessively high humidity and subsequent condensate can damage or destroy not only the fabric of the building, but also any stored objects.

Non-residential buildings also include public buildings, restaurants, offices, training rooms and schools.

#### Buildings with high occupancy

A high $CO_2$ concentration and a low $O_2$ concentration quickly lead to fatigue, inability to focus, feeling generally physically unwell and headaches. It is particularly important to ensure high air quality in buildings with high occupancy.




X Occupancy time in hours (h)
Y $CO_2$ concentration (% by vol.)
1 Air change rate = 0
2 Hygienic limit
3 Air change rate = 0.5
4 $CO_2$ content of fresh air

#### Nurseries and schools

High air quality as a result of controlled air change with filtered air also ensures a reduction in pollen, bacteria and viruses in the indoor air. The risk of becoming ill or infected as a result of aerosol transmission is considerably reduced and the pollen load drops.

# System selection

### Ventilation systems

A differentiation is made between centralised and decentralised ventilation systems.

### Centralised ventilation systems

With a centralised ventilation system, the individual rooms are connected via air ducts to a centralised ventilation unit.

### Decentralised ventilation systems

With a decentralised ventilation system, separate ventilation units are installed in the external walls of the individual rooms. The individual units are connected via a control unit. These units are also known as reversible fans, because the air flow through the units changes direction at regular intervals. Another term is thermal fan, because the thermal energy in the air is stored when the air flow direction changes and can continue to be used.

### Choosing a ventilation system

For each building, it is necessary to check whether a decentralised or centralised ventilation system should be used.

It is not possible to generalise which type of system will be appropriate for a given setting, as the decision for one system or another always depends on multiple factors. The decision may also be based on personal or regional experiences.

# System recommendations

**Prefabricated single-family house**

Prefabricated house manufacturers generally offer a complete solution with integral ventilation system.

**Modernised prefabricated house**

When older prefabricated houses without a ventilation system are modernised, the installation of a decentralised ventilation system is ideal.

**New build – detached house**

In new build single-family houses, both systems can be used.

The decision can be made using a cost calculation.

**Modernised single-family house**

During the modernisation of single-family houses, the scope of the modernisation and the structural conditions are key when choosing a system.

If only the windows are being replaced and the façades insulated, then the simultaneous installation of a decentralised ventilation system is an option.

If the building interior is being completely stripped back to its shell, then a centralised ventilation system can also be retrofitted.

The decision can be made using a cost calculation.

**New build apartment building**

In principle, both systems can be used in new build apartment buildings.

In practice, centralised ventilation systems working independently of one another have proved successful. This lowers the installation complexity.

In larger properties, decentralised ventilation systems are increasingly being used for economic reasons.

**Modernised apartment building**

Decentralised ventilation systems are the preferred option in modernised or partially modernised apartment buildings.

**Non-residential building**

For storage rooms, public buildings and restaurants, centralised ventilation systems and decentralised ventilation systems are an option.

For private garages, decentralised ventilation units can be used.

**Buildings with high occupancy**

In new and existing office buildings, co-working spaces or meeting rooms, both centralised and decentralised ventilation systems are used.

**Nurseries and schools**

In nurseries and schools, both centralised and decentralised ventilation systems are used.

**Basement rooms**

For basement rooms, special basement fans with integral humidity and temperature capture are an option.

**Humidity**

Humidity is an important parameter indicating the moisture content of the air.

Humidity is based on the proportion of water vapour in the air. It is generally specified as relative humidity (RLH), indicating the ratio of actual water vapour content to maximum water vapour volume at a specific temperature.

Humidity can have a significant effect on human wellbeing. High humidity can lead to a sweltering and unpleasant atmosphere, whereas low humidity can dry out the skin and irritate the airways. Moderate humidity content, usually between 40 % and 60 % RLH, is considered comfortable.

Humidity can also affect health. High humidity encourages the growth of mould fungus and house dust mites, which can exacerbate allergies and respiratory problems. Low humidity can lead to dry mucous membranes, irritation of the airways and increased susceptibility to respiratory infections.

Humidity also plays a role in the conservation of materials. Excessively high humidity can damage susceptible objects such as wood, paper or electronic devices. Low humidity can lead to the formation of cracks and cause materials to dry out.

Humidity can be measured with hygrometers, which are used in indoor spaces, weather stations and industrial applications.

Humidity varies subject to the location and climate. In tropical regions, humidity is generally high, whereas in desert regions, it can be low. Seasonal fluctuations can also occur, e.g. higher humidity in summer and lower humidity in winter.

It is important to monitor the humidity in indoor spaces and, if required, to take measures to maintain a moderate moisture content, ensuring comfort, health and protection of materials.

**The difference between relative and absolute humidity**

Relative humidity (RLH) is the ratio of current water vapour in the air to maximum quantity of water vapour that the air can contain at the same temperature. It is expressed as a percentage and indicates how much moisture the air actually contains compared with the maximum it could absorb at this temperature. A relative humidity of 100 % means that the air is saturated with water vapour and cannot absorb any more water vapour, whereas a relative humidity of 50 % means that the air contains half of the maximum quantity of water vapour that it could absorb at this temperature.

Absolute humidity (ALH) is the actual quantity of water vapour present in the air, irrespective of the maximum absorption capacity of the air at this temperature. It is measured in grams of water vapour per cubic metre of air. Absolute humidity indicates the quantity of water vapour that is contained per volume unit in the air.

To clarify the difference: Relative humidity can change depending on whether the air temperature rises or falls, as this changes the maximum absorption capacity. Absolute humidity remains constant as long as no water vapour is added or removed.

**Summary:**

Relative humidity indicates the ratio of water vapour content to maximum absorption capacity of the air at the same temperature.

Absolute humidity indicates the actual quantity of water vapour in the air, irrespective of the maximum absorption capacity.

### Mollier or hx diagram

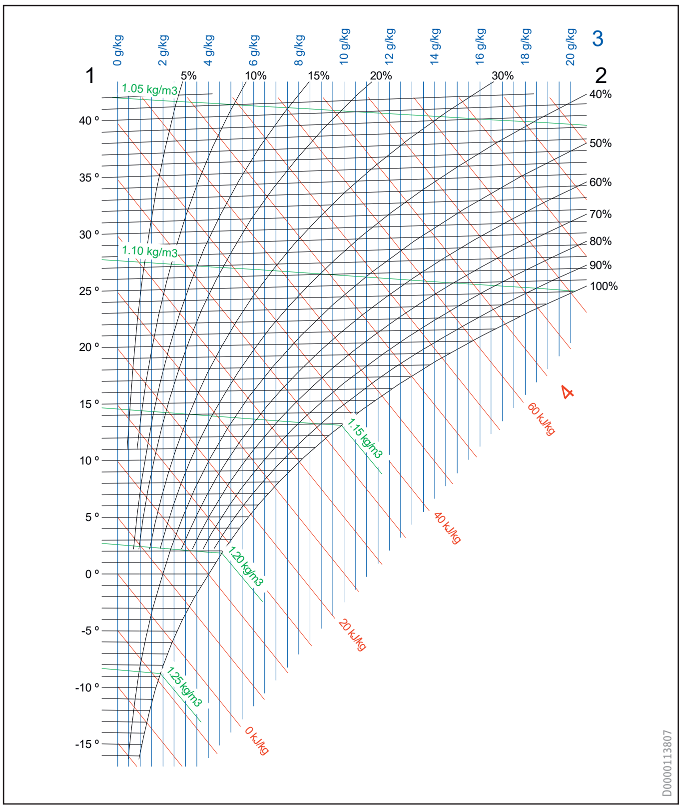
The hx diagram, also known as a Mollier diagram or enthalpy diagram, is a diagram used in thermodynamic and technical building system design to represent properties and states of moist air. It shows the relationship between the specific enthalpy (h) and moisture content (x) of the air.

Specific enthalpy (h) is the total energy per kilogram of dry air and includes the sensible heat (based on the temperature) and the latent heat (based on the evaporation or condensation of the water vapour in the air).

The moisture content (x) indicates the ratio of water vapour mass to total mass flow of moist air. It is generally expressed in kilograms of water vapour per kilograms of dry air.

The hx diagram enables various states of the air to be represented, including temperature, moisture content, specific enthalpy, specific volume and other properties. It offers a visual representation of the thermodynamic processes that can occur with moist air, e.g. heating, cooling, humidification and dehumidification.

The hx diagram is a tool for engineers, energy experts and technicians to analyse air states, produce energy statements, draft processes and evaluate the performance of air conditioning systems, cooling systems, and other air-based systems.




Mollier hx diagram for moist air, pressure 950 mbar (537 m / 10 °C / 80 % RH)

1 Temperature
2 Relative humidity
3 Water
4 Enthalpy

### Humidity protection

There are two critical reasons to ventilate buildings:

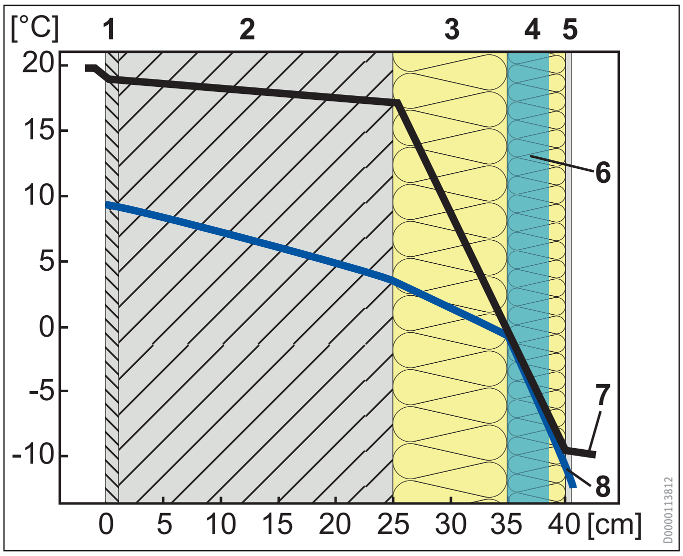
» Health protection
» Building protection

Both reasons involve balanced indoor air humidity.

Excessively high humidity leads to two interconnected problems:

Moist indoor air can, for example, cool on or in a cold external wall, causing condensate to form. In conjunction with surrounding organic materials, the condensate forms a breeding ground for mould. Organic materials are, for example, carpets, the wall material and insulation in the wall.

The fabric of the building subsequently becomes damaged by mould growth.




1 Interior plaster (10 mm)
2 Brickwork (240 mm)
3 Rigid foam EPS (100 mm)
4 Rigid foam EPS (50 mm)
5 Exterior plaster (5 mm)
6 Dew/condensate
7 Temperature
8 Dew point

Excessively high humidity negatively affects the perception of comfort. If indoor air is perceived to be humid, this negatively impacts on physical wellbeing. Performance and concentration are reduced.

Excessively high humidity leads to mould growth on the fabric of the building. Mould and fungus are bad for the health of people and animals.

**Air quality**

Humidity, odours, dust, pollen, radon and $CO_2$ content are important factors for air quality.

Cooking produces odours. Building materials, wooden and plastic objects, people and pets create odours and vapours.

Dust and pollen can trigger allergic reactions in people and pets.

Radon is a naturally occurring radioactive gas. Radon occurs at ground level. At a high concentration, radon is carcinogenic.

Carbon dioxide is a non-toxic odourless gas, which is produced in metabolic processes and in all processes involving the combustion of material containing carbon. Depending on the season and local conditions, the $CO_2$ concentration of the outdoor air between 0.03-0.05 % proportional volume.

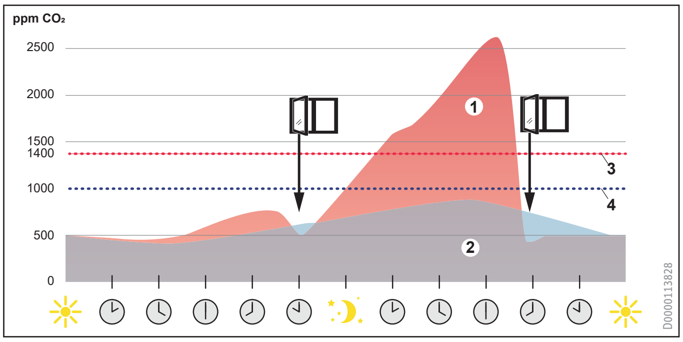
Human wellbeing is linked to the $CO_2$ content of the indoor air.

| $CO_2$ concentration | | Wellbeing |
|---|---|---|
| <0.1 | % | Comfortable |
| 0,1 - 0,15 | % | AIVC standard value |
| >0.2 | % | Uncomfortable |
| 0,5 | % | Still harmless |
| >1 | % | Adverse effects |

If a $CO_2$ concentration of 0.1 % is reached, the indoor air is considered to be “stale”.

A study by the Air Infiltration and Ventilation Centre (AIVC) sets out reference $CO_2$ concentration values of between 0.1 % and 0.15 %. $CO_2$ is not harmful even at higher concentrations of up to 0.5 %. From a 1 % $CO_2$ content in the indoor air, adverse effects such as fatigue and headaches occur.

The $CO_2$ concentration in indoor air fluctuates subject to the use pattern and the number of occupants in the room.




1 Window ventilation
2 Convenient room ventilation
3 Requirement according to SIA standard 382
4 Pettenkofer value

It is not possible to maintain a $CO_2$ concentration level below 1400 ppm (SIA standard 382) through window ventilation.

Air pollution is often expressed as a percentage to describe the proportion of certain pollutants in the air. However, in order to carry out more accurate measurements and comparisons, it is also often specified in “ppm” (“parts per million”) for a more precise definition of the concentration of these pollutants.

In this context, it is important to understand how the percentage can be converted into ppm for a more accurate analysis of the air quality and its effects.

### Heat recovery

For ecological and economic reasons, ventilation systems have heat recovery. Heat recovery can be based on various technologies.

Decentralised ventilation units each have an integral heat exchange section. The heat exchange section absorbs energy from the warm exhaust air and transfers this energy to the inflowing cold supply air when the air direction changes. These integral heat exchange sections are made up of a material with extremely rapid heat absorption and heat transfer.

Decentralised mixer systems can also include extract air fans without separate heat recovery if the entire system meets the energy efficiency requirements.

Special extractors also include a refrigeration unit, which draws energy from the outflowing warm exhaust air and transfers this energy to an internal or external DHW cylinder.

Centralised ventilation systems have an integral air-air heat exchanger, which draws energy from the warm exhaust air via contact surfaces and transfers this energy to the inflowing cold supply air.

Highly integrated centralised ventilation systems also have a heat pump. This heat pump actively draws energy from the outflowing warm exhaust air. The energy is transferred to an integral DHW cylinder and the heating system.

# Indoor air cooling

## Indoor air cooling

### Passive cooling

Passive cooling with ventilation units utilises natural air currents and air temperatures to reduce the room temperature without the need for active air conditioning.

Ventilation units are set up so that, during cooler times of the day or overnight, they bring cold air into the building from outside and expel warm air outdoors.

During hot times of the day, the ventilation units are switched off or the flow rate is reduced to minimise the ingress of warm outdoor air.

For optimum indoor air cooling, it is important to minimise insolation in the building. Windows can be fitted with suitable curtains, blinds or sun protection films.

If the humidity in a room is too high, passive cooling cannot function effectively. The humidity should be monitored by the ventilation unit and ventilation should be regulated automatically or according to demand.

Passive cooling with ventilation units is more ecological and economical than active air conditioning with air conditioning systems. The output of a passive cooling system is lower than that of an active air conditioning system, particularly at extreme temperatures or in very high humidity.

### Active cooling

Active cooling of the indoor air is carried out through the use of air conditioning or cooling systems.

Air conditioning systems move the air whilst cooling it. There are various types of units, such as split air conditioning systems, centralised air conditioning systems, ventilation systems and mobile local air conditioning units.

The principle of active cooling with ventilation units is based on the generation of cool air through the use of a refrigeration unit. The cooled air is routed via the ventilation unit into the room or area to be cooled. This means that the air temperature and humidity can be regulated depending on the settings of the air conditioning system.

The air conditioning system absorbs the moisture from the indoor air and expels it outdoors. This occurs either through a centralised venting system or through a condensate drain system.

To improve efficiency and effectiveness, ventilation units can be equipped with sensors and control units, which automatically match cooling to the indoor air temperature and energy demand.

### Sound

In an air duct system, the main sources of noise are the fan and the flow noise from the fittings.

Sound can be propagated in different ways:

» Sound emission via the casing walls to the installation room.

» Structure-borne noise transmitted to the foundations. In simple ventilation units, this can be prevented through the use of anti-vibration mounts.

» Airborne sound is produced by the suction connector and the pressure connector. This sound is absorbed to some extent through the acoustic characteristics of the air routing system, the silencer and the relevant room.

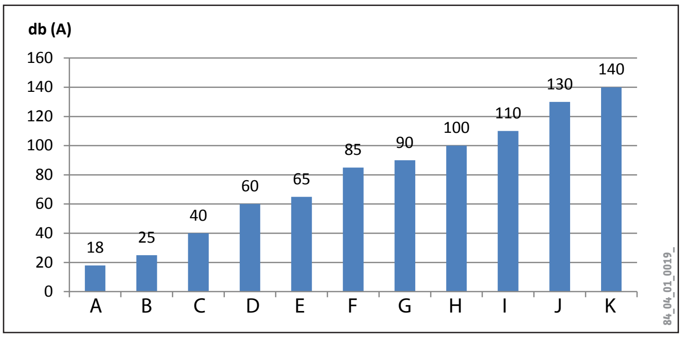
The airborne sound emitted by both fans of a centralised ventilation unit is reduced by two silencers on the room side, in the supply and extract air ducts.

The air routing system components generate flow noise. Their sound power is absorbed by the system between the air duct components and the room.

The air outlets in the rooms are a further source of noise.

### Example values for sound immissions

The sound emissions of a typical ventilation system are comparable to noise in a bedroom.




A Forest
B Bedroom
C Living space or library
D Entertainment
E Office
F Average road traffic
G Heavy traffic
H Pneumatic hammer
I Pop/rock concert
J Jet aircraft starting at a distance of 100 m
K Jet engine at a distance of 25 m (pain threshold)

### System design

» Air ducting must be correctly sized in compliance with country-specific standards.

» Ventilation duct connections to a centralised ventilation unit must be flexible to prevent the transmission of structure-borne sound.

» To minimise appliance noise, silencers must be provided directly downstream of a centralised ventilation unit in the supply air and extract air duct.

» To prevent sound transmission in an air duct system, crosstalk silencers must be installed at suitable points.

» Supply air and extract air vents must be installed and set up in accordance with the manufacturer's instructions.

» To minimise noise pollution, the air flow rate per air vent must be as low as possible and, if required, multiple air vents with separate supply lines should be incorporated into the design.

# Sound

### Ventilation units with integral heat pump

» When installing, ensure that no structure-borne noise transmission can arise inside the building.

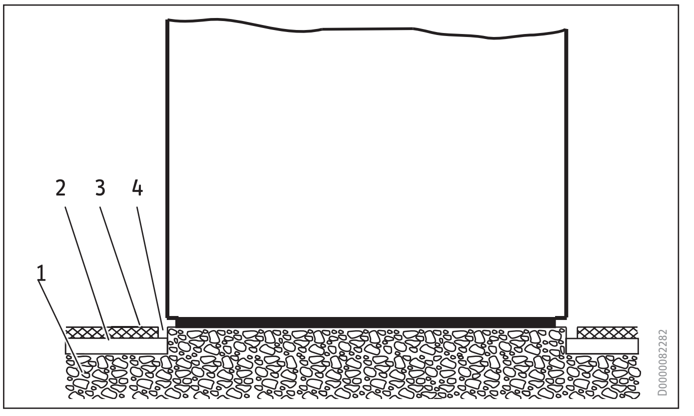
» Installation on floating screed is possible if the screed has been applied professionally. Screed must be detached from walls and adjacent rooms.

» With a wooden joist ceiling, the base on which the unit stands must be reinforced with, for example, multiple OSB boards screwed together on a sound insulation mat.

» To prevent noise pollution through airborne sound, avoid siting the unit in the immediate vicinity of living spaces and bedrooms, especially near internal partition walls. Otherwise, sound attenuation measures are necessary in this case as well, e.g. sound attenuation of a higher standard for the internal wall.

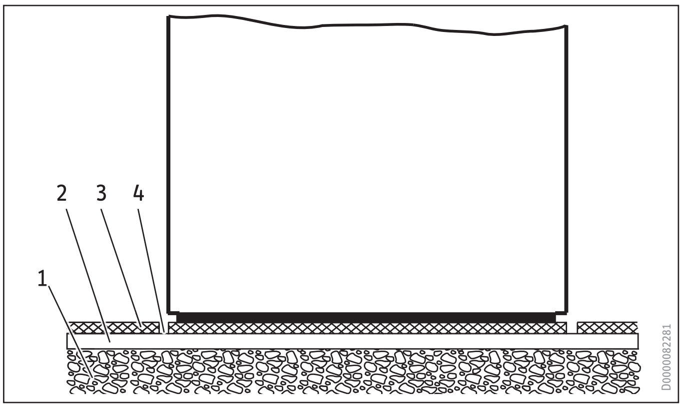
» Outdoor air and extract air apertures should not be directed towards the windows of neighbouring living spaces or bedrooms.

### Installation on foundations




1 Concrete base
2 Impact sound insulation
3 Floating screed
4 Screed recess

### Installation on screed with impact sound insulation




1 Concrete base
2 Impact sound insulation
3 Floating screed
4 Screed recess

## Notes

### Window ventilation

During window ventilation, indoor air in the apartment is exchanged through the prevailing wind conditions by opening windows and doors.

» Dust and pollen enter the apartment

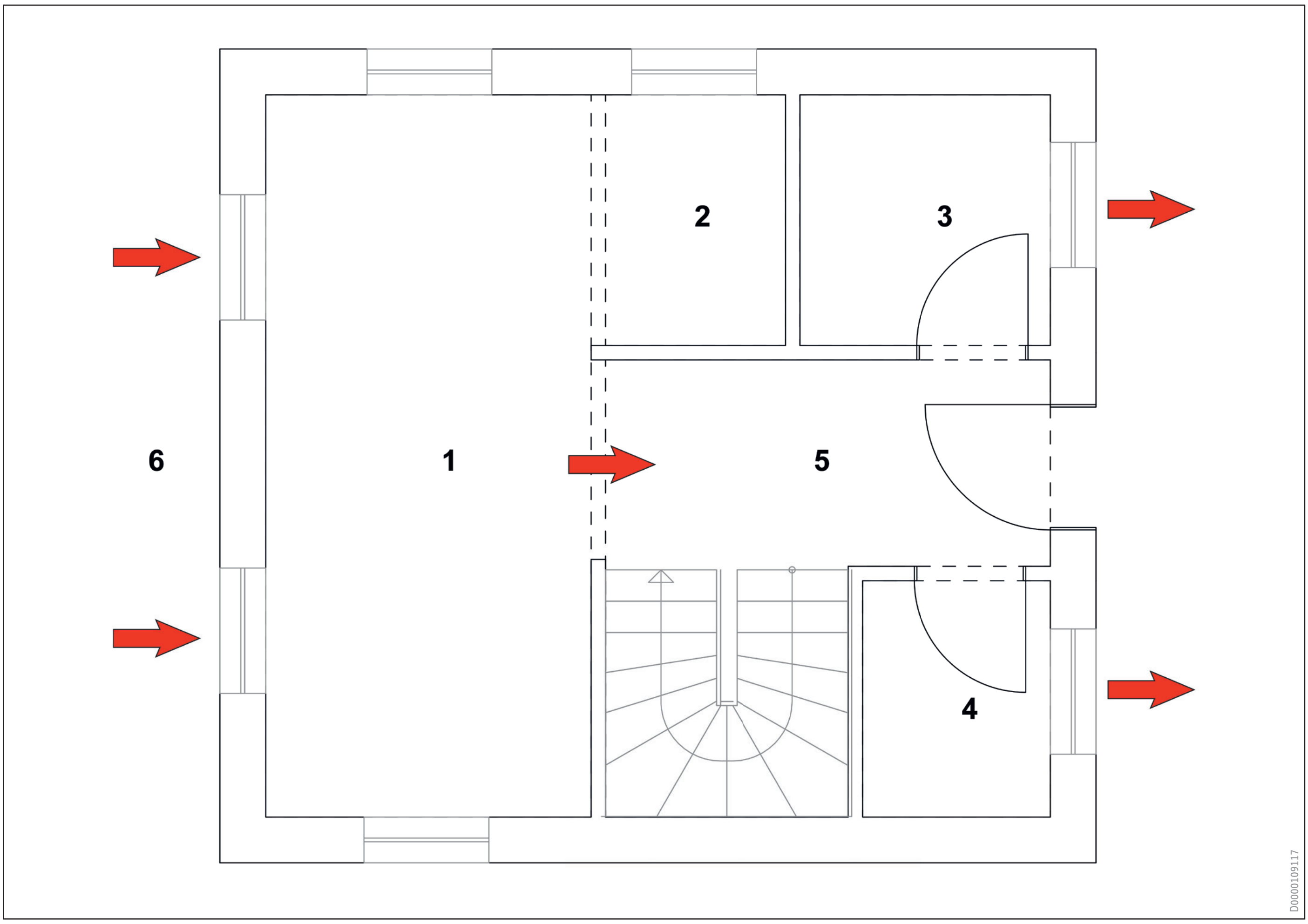
» Rain and snow enter the apartment

» There is a high level of noise pollution in the apartment

» The air change rate cannot be controlled

» Ventilation is only possible during the waking hours of the occupants present

» Over 50 % ventilation heat losses in the heating period.



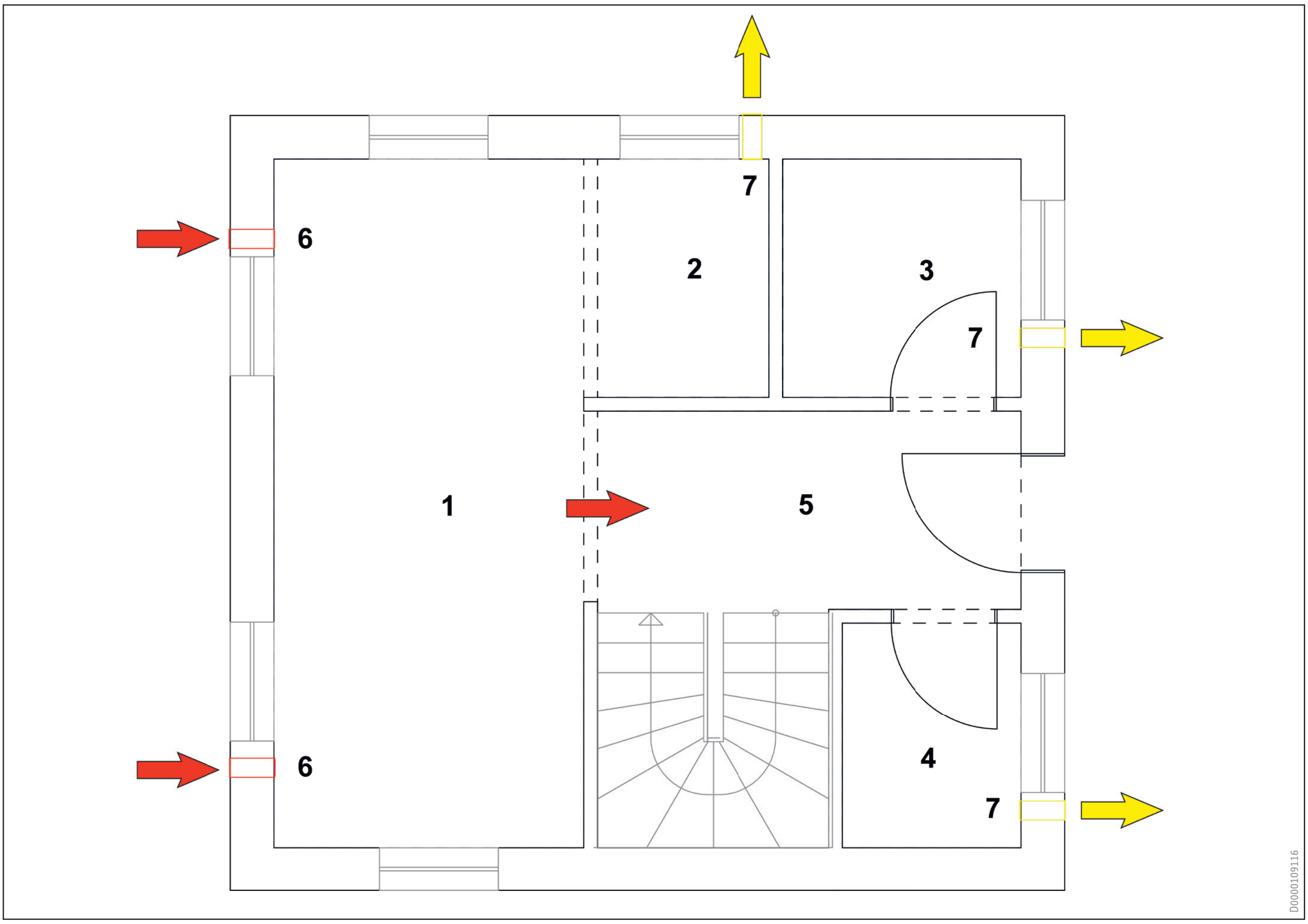

1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Main wind direction (windward side)

**Decentralised ventilation - extract air**

During extract air ventilation, the indoor air is sucked out of the extract air areas and expelled outdoors. Fresh outdoor air flows into the supply air areas via the air vents built into the external walls.

» There is no heat recovery.

» Over 50 % ventilation heat losses in the heating period.




1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Outdoor air diffusion (ALD)
7 Extract air fan

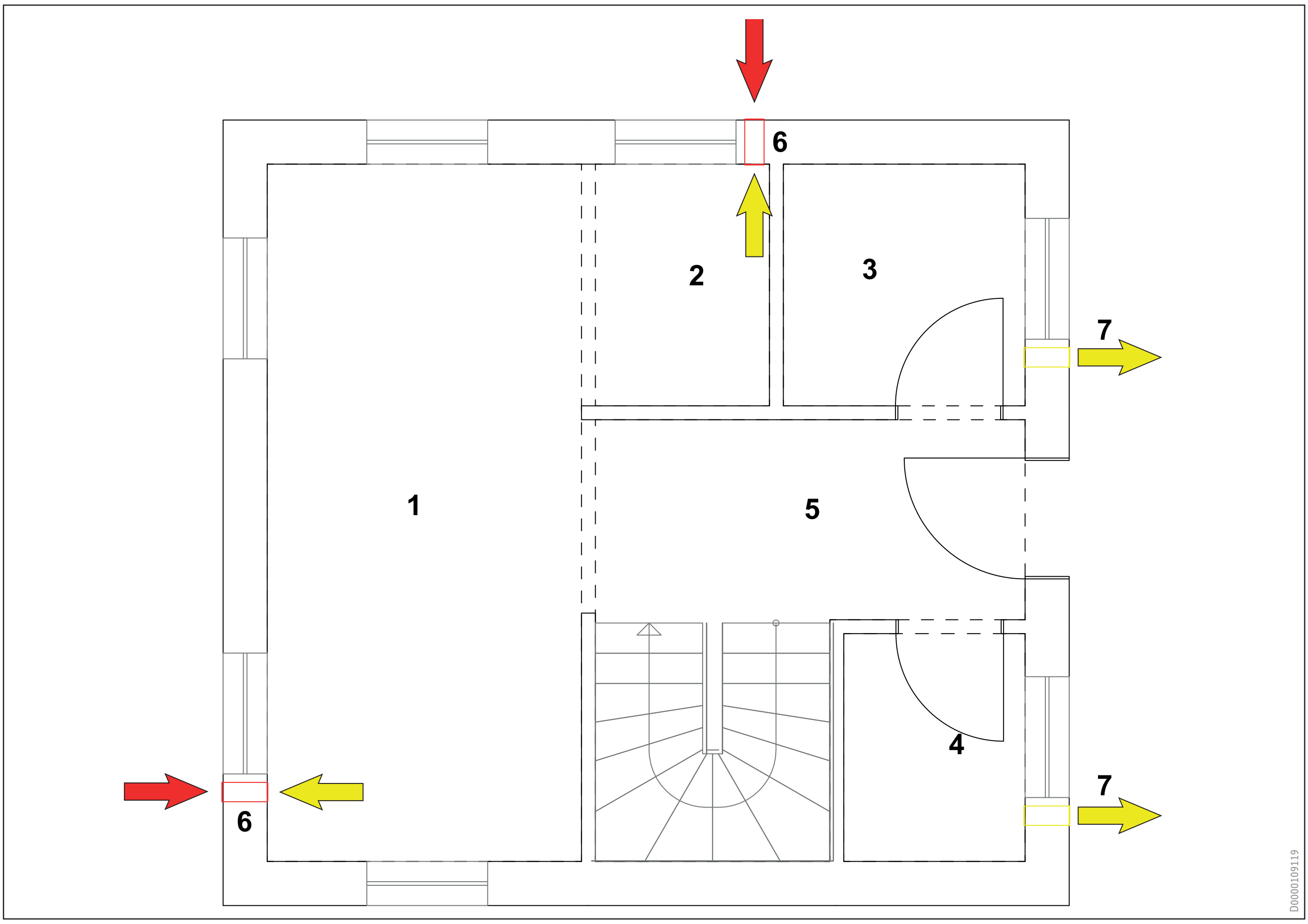
**Decentralised ventilation - supply and extract air**

Living room, dining room and kitchen are considered as a combined space in this mixed system.

The supply air areas are ventilated with decentralised ventilation units. The extract air areas are ventilated with extract air fans.

» There is only partial heat recovery

» There are minimal ventilation heat losses in the heating period.




1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Supply/extract air fan
7 Extract air fan

### Extract air heat pump

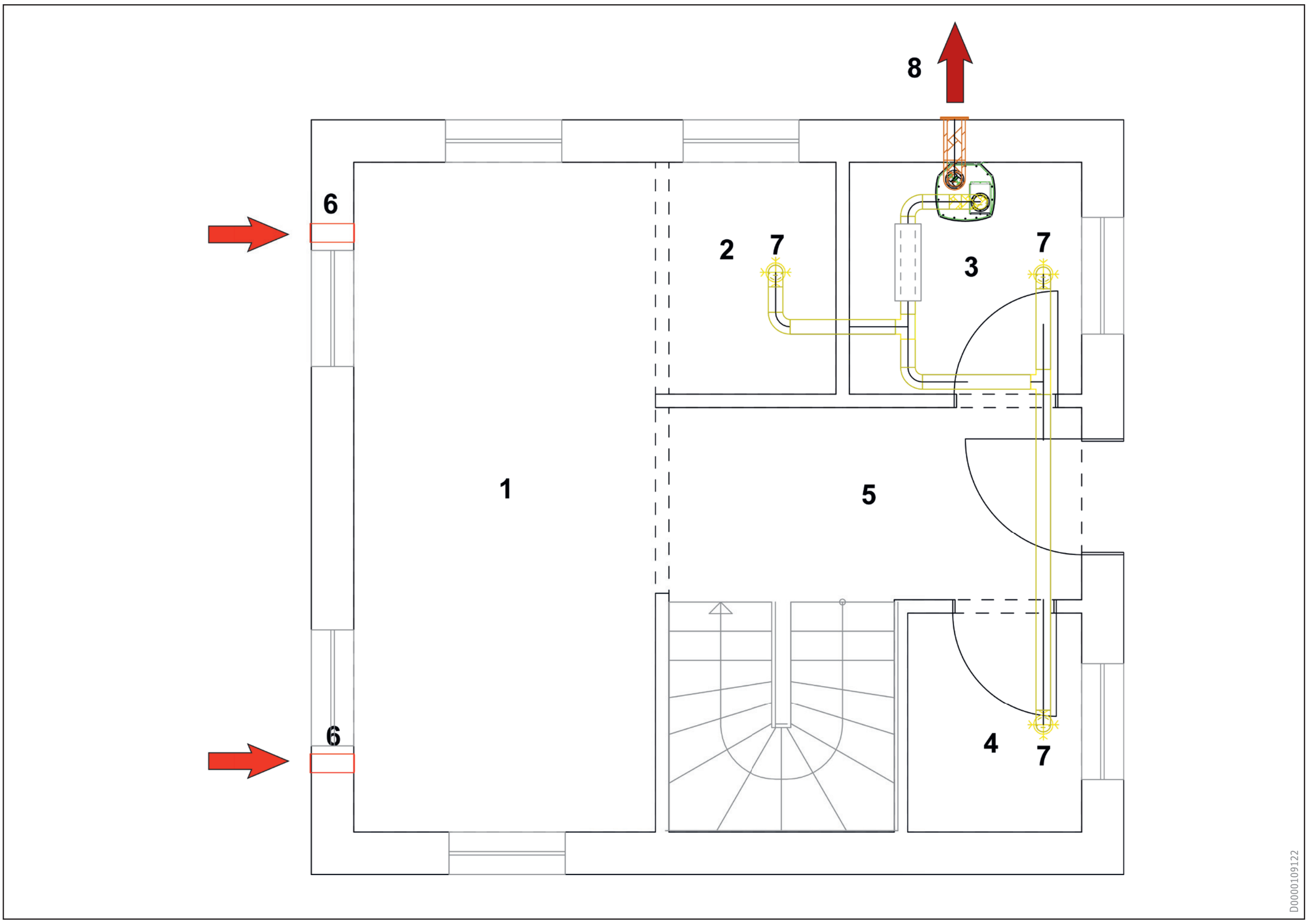
Extract air flows are routed with an air duct system via a ventilation unit with heat recovery through a heat pump and to a DHW cylinder. The recovered energy is utilised for DHW heating. Fresh outdoor air flows into the supply air areas via airflow vents built into the external walls.

» Controlled air change exists in all areas.

» Active heat recovery occurs with a heat pump.

» Heat recovery can be incorporated into DHW heating.

» There are minimal ventilation heat losses in the heating period.




1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Supply air vent
7 Extract air vent
8 Outdoor and exhaust air

# Centralised ventilation - supply and extract air

### Centralised ventilation - supply and extract air

The extract air and supply air flows are routed using an air duct system via a ventilation unit with heat recovery.

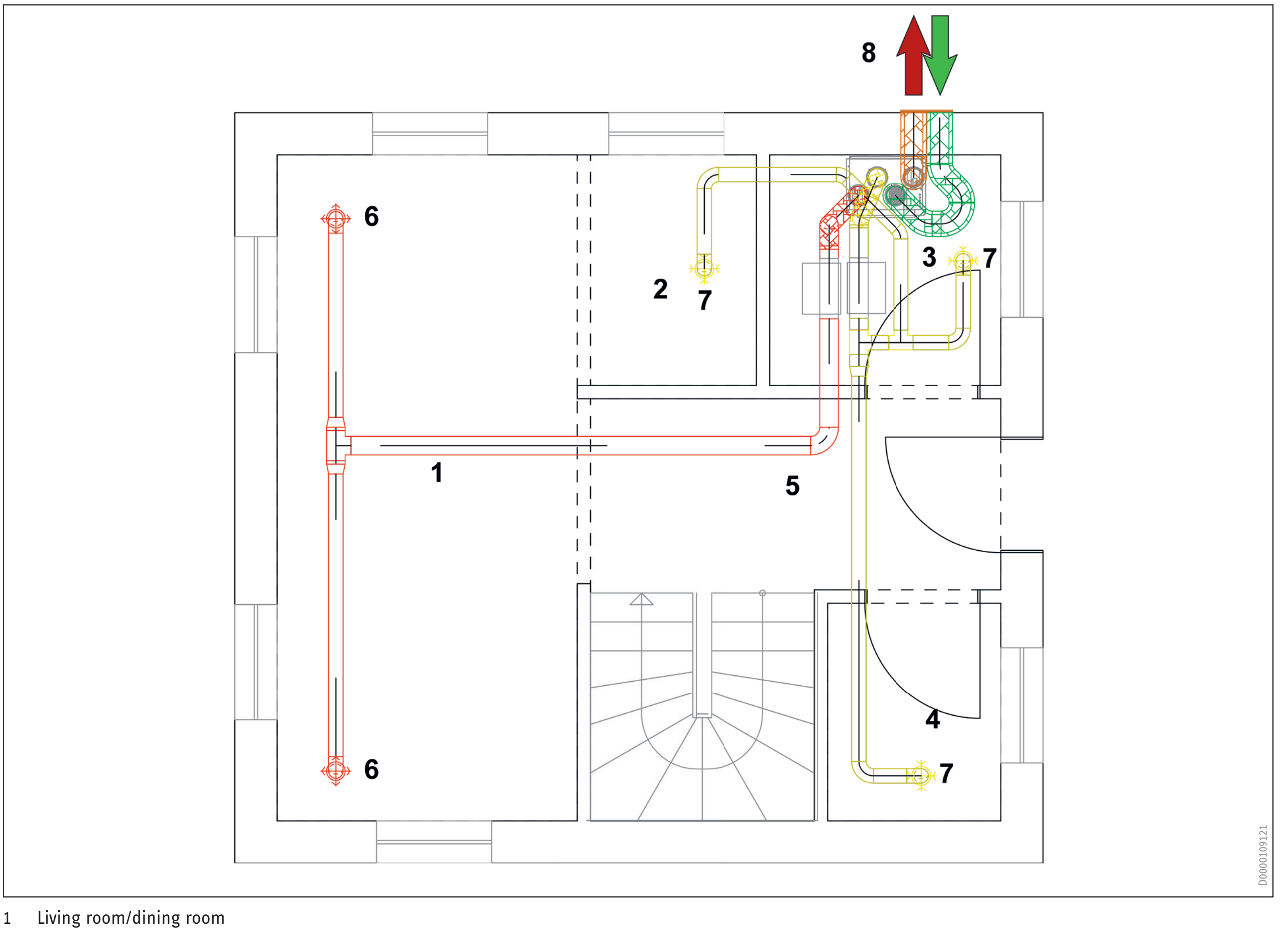
» Controlled air change exists in all areas.

» Active heat recovery occurs with a heat pump.

» Heat recovery can be incorporated into DHW heating.

» Heat recovery can be incorporated into room heating.

» There are no uncontrolled ventilation heat losses.

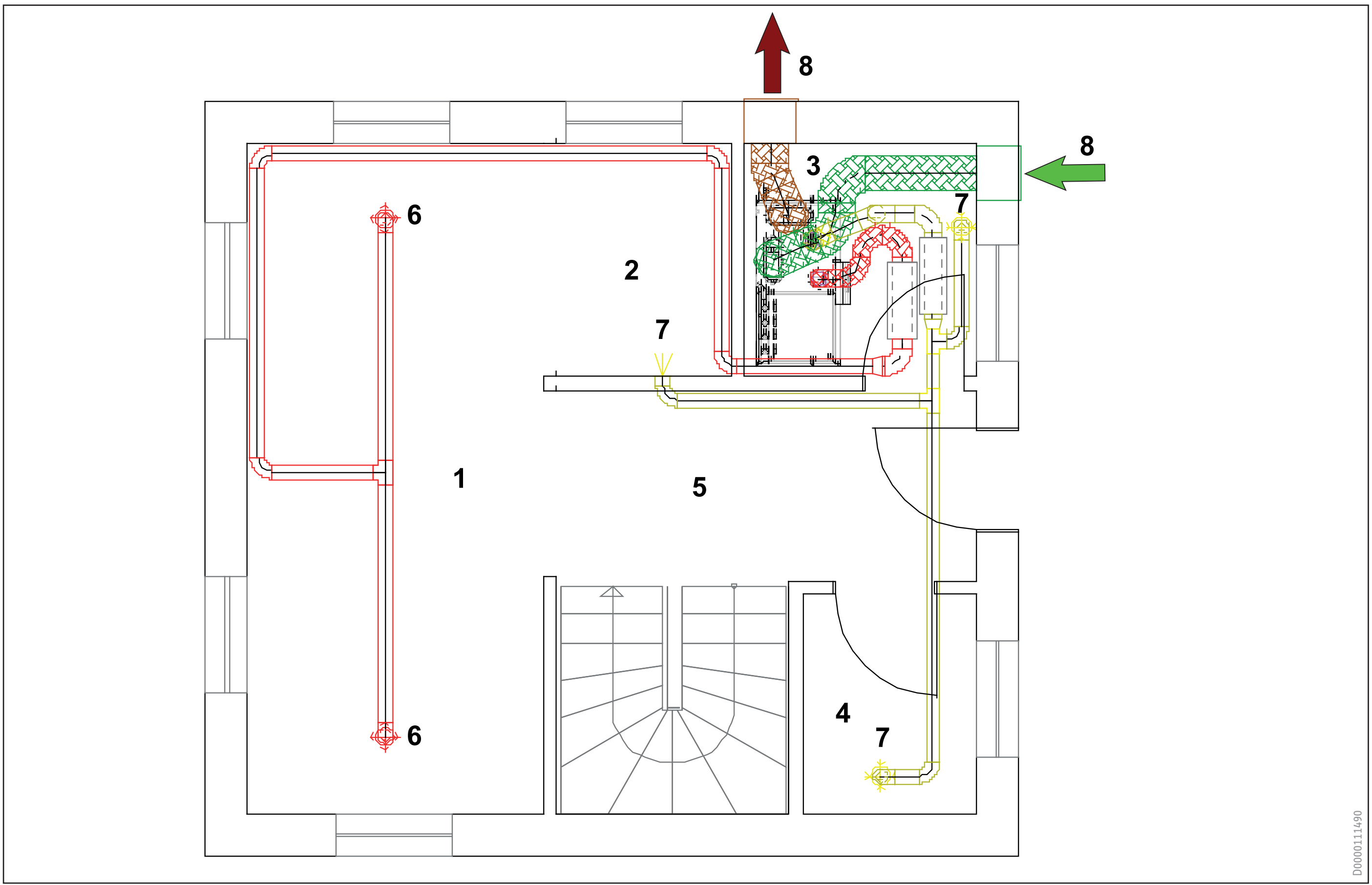



1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Supply air vent
7 Extract air vent
8 Outdoor and exhaust air

### Centralised ventilation with DHW cylinder and heating

The extract air and supply air flows are routed using an air duct system via a ventilation unit with heat recovery. In conjunction with an integral heating heat pump, recovered energy is used for DHW heating and hydraulic building heating.

- Controlled air change exists in all areas.
- Active heat recovery occurs with a heat pump.
- Heat recovery is incorporated into DHW heating.
- Heat recovery is incorporated into room heating.
- There are no uncontrolled ventilation heat losses.

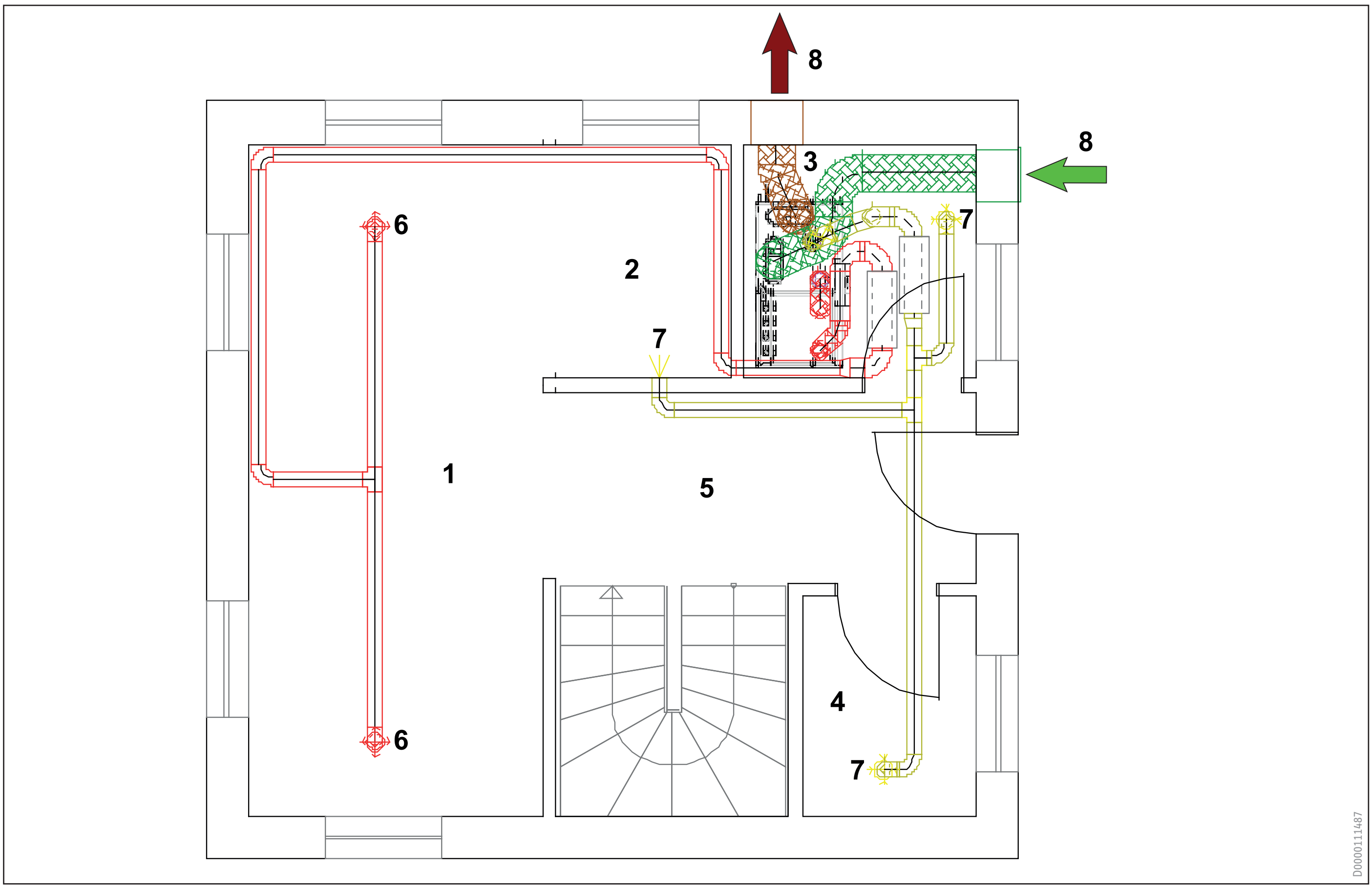



1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Supply air vent
7 Extract air vent
8 Outdoor and exhaust air

### Centralised ventilation with air heating

The extract air and supply air flows are routed using an air duct system via a ventilation unit with heat recovery. Controlled heating of the supply air is carried out by an integral heat pump.

- » A single system is responsible for mechanical ventilation and heating of living spaces.
- » Controlled air change exists in all areas.
- » Active heat recovery occurs with a heat pump.
- » Heat recovery is incorporated into DHW heating.
- » Heat recovery is incorporated into room heating.
- » There are no uncontrolled ventilation heat losses.




1 Living room/dining room
2 Kitchen
3 Utility room
4 WC and shower
5 Entrance
6 Supply air vent
7 Extract air vent
8 Outdoor and exhaust air

# Influence on heating energy demand

**Ventilation and heating costs**

Germany:

The minimum requirements for the current energy standard of a building correspond to “KfW 55 standard”.

A higher building energy standard is “KfW 40 standard”.

» A KfW Efficiency House 55 has an energy demand 45 % below the legal requirements.

» A KfW Efficiency House 40 has an energy demand 60 % below the legal requirements.

**Comparison of the heating energy demand**

Irrespective of “building protection” and “health protection” factors, ventilation systems also reduce the heating energy demand $Q_{h,b}$.

Depending on the building type and the ventilation system used, a reduction in the heating energy demand of over 30 % can be achieved.

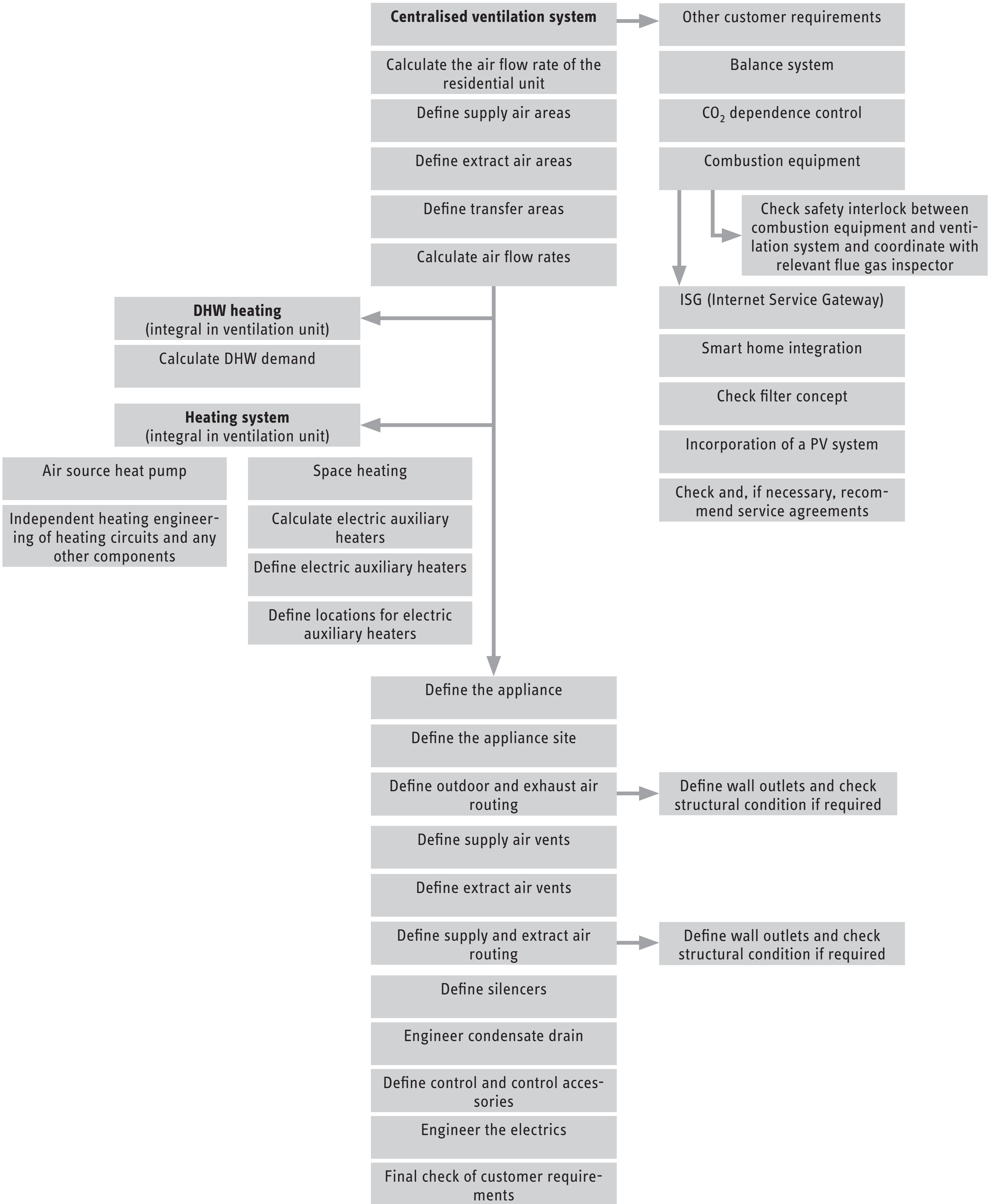
Example:

The building used for the calculation is a single-family house with a floor area of approx. 150 m².

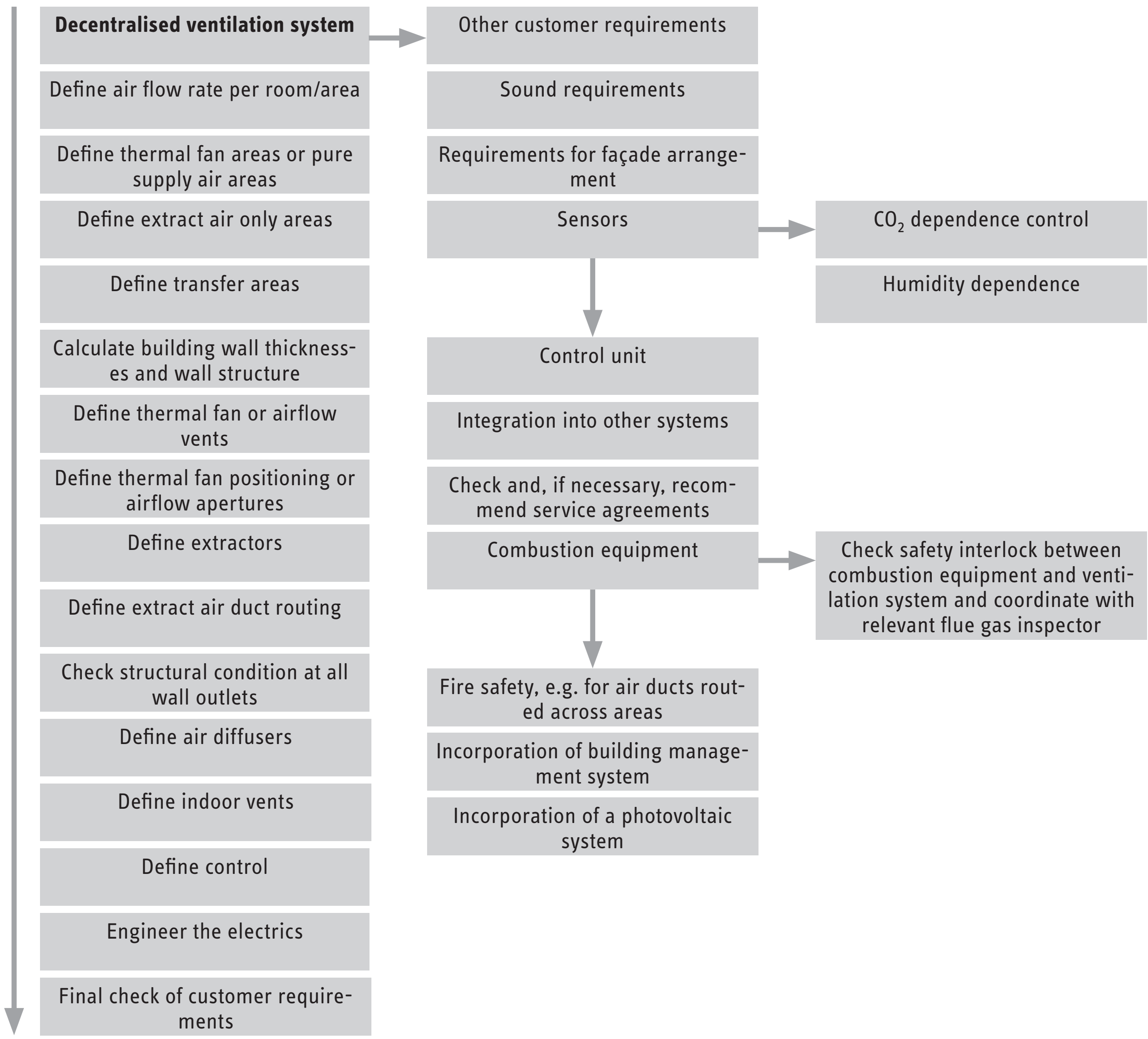
| No. | Building | | Ventilation | Heat pump | Qh,b * kWh/a | Saving % |
|---|---|---|---|---|---|---|
| 1 | Current energy standard | KfW 55 | without | Air source heat pump | 7367 | 0 |
| 2 | Current energy standard | KfW 55 | Extract air ventilation | Air source heat pump | 6883 | 6,6 |
| 3 | Current energy standard | KfW 55 | Heat recovery | Air source heat pump | 4701 | 36,2 |
| 4 | Higher energy standard | KfW 40 | without | Air source heat pump | 5710 | 0 |
| 5 | Higher energy standard | KfW 40 | Extract air ventilation | Air source heat pump | 5597 | 1,5 |
| 6 | Higher energy standard | KfW 40 | Heat recovery | Air source heat pump | 3526 | 29,6 |

The saving achieved through heat recovery covers the energy demand of the ventilation unit.

# Centralised ventilation systems



# Decentralised ventilation systems



# Zones

### General design of ventilation systems

Various country-specific standards, guidelines and specifications exist for the design of ventilation systems.

At this point, we will give a general overview of design aspects.

### Building zoning

The division of the individual building rooms or sections into supply air and extract air areas, as well as transfer areas, forms the basis of any ventilation system design.

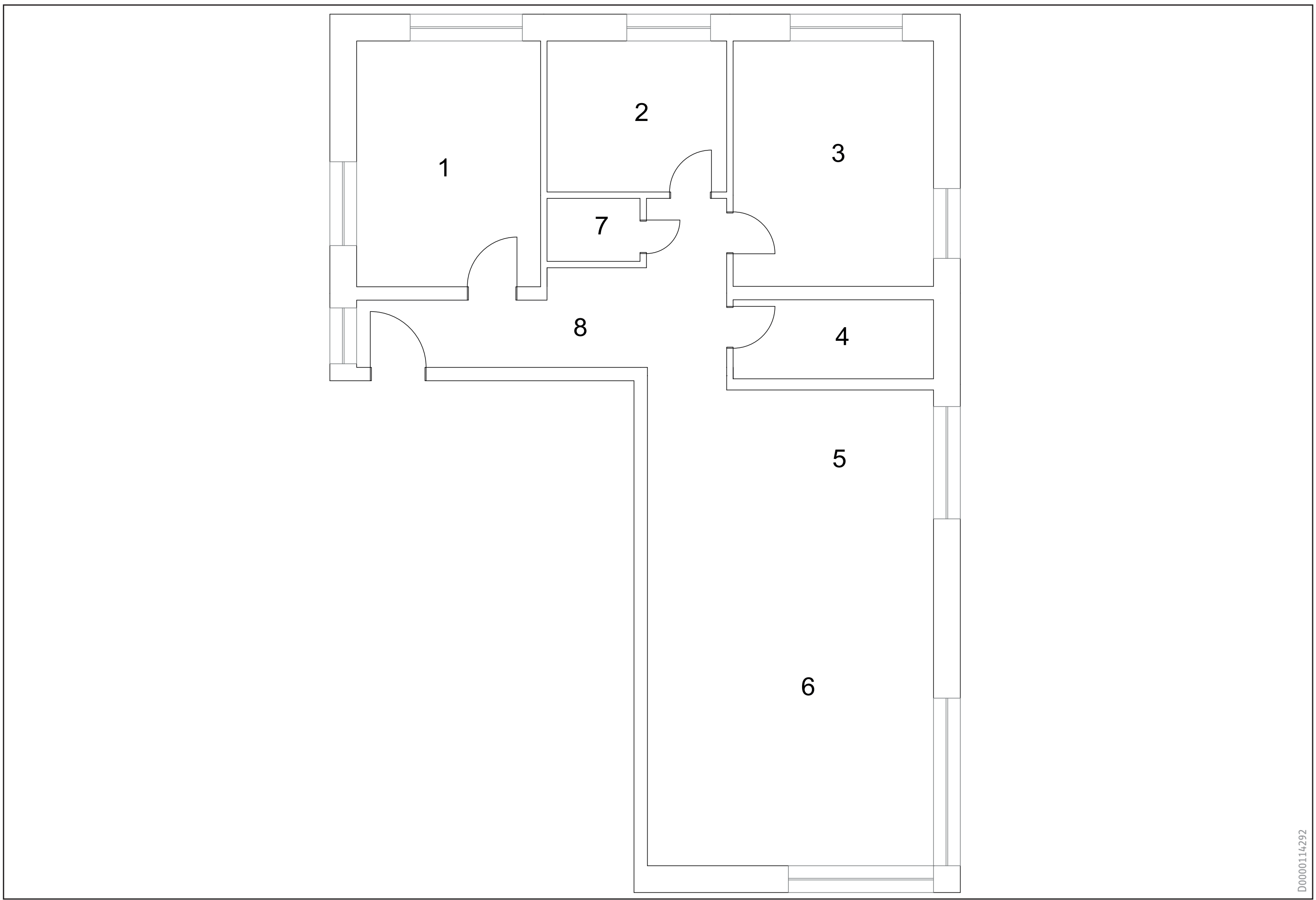
Supply air areas are spaces characterised by their use in a similar way to living spaces, e.g. living rooms, bedrooms and children's rooms. These areas have high air quality requirements, calling for a continuous supply air flow rate.

Extract air areas are spaces where moisture loads occur, e.g. bathroom, WC, shower and kitchen. In these areas, the priority is expelling moisture.

Division into supply air and extract air areas creates positive pressure in supply air areas and negative pressure in extract air areas. This pressure differential is offset by transfer areas, e.g. a hallway. To enable transfer, suitable flow paths must be provided, for example shortened doorways.

### Example of zoning in a 3-bedroom apartment

| Supply air | Transfer area | Extract air |
|---|---|---|
| Living room | Hallway/entrance | Kitchen |
| Bedroom | | Bathroom |
| Children's rooms | | Guest toilet |
| | | Utility room |




1 Children's rooms
2 Bathroom
3 Bedroom
4 Utility room
5 Kitchen
6 Living room
7 Guest toilet
8 Hallway/entrance

# Outdoor air

**Outdoor air intake**

When it comes to outdoor air intake, several points must be taken into consideration to ensure functionality and prevent noise pollution.

Outdoor air intake and exhaust air discharge must be at a sufficient distance away from one another to prevent a thermal short circuit and the transmission of odours. Observe a sufficient clearance from chimneys and other flue gas sources.

Air intake on the road side or from a car port should be avoided to minimise the ingress of pollutants.

High indoor air quality is supported through the appropriate positioning of the outdoor air intake to prevent the ingress of dust, pollen and bacteria. Additional filters can be used if required.

Outdoor air should be drawn in as far above ground level as possible to avoid the intake of radon, a radioactive gas that is harmful to lungs. Intake in narrow pits and shafts is generally not permissible and should always be avoided.

# Notes

**Air flow rate calculation**

The air flow rate is calculated according to the standards and regulations of the relevant country.

National standards and regulations vary with regard to air flow rate per room/area and the overall design.

A ventilation system should therefore always be designed by an engineer with the requisite specialist expertise.

# Air flow rate calculation (Germany)

### Calculating the nominal flow rate

The total nominal flow rate is determined according to the floor area or the sum of the extract flow rates, whereby the higher value is decisive.

The following conditions must be observed:

» The total extract air flow rate should only be 20 % higher than the nominal flow rate by area.

» If the total extract air flow rate is more than 20 % higher than the nominal flow rate by area, then the extract air flow rate of the other rooms/areas must be reduced.

» Extract air flow rates of other rooms should only be reduced by a maximum of 50 %.

Notice: A significantly higher total extract air flow rate arises when there are lots of rooms with high moisture levels, e.g. additional bathrooms, training rooms and sauna areas.

### Nominal flow rate by area

| Nominal flow rate by area | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Living space | m² | 20 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 |
| Nominal ventilation | m³/h | 35 | 45 | 65 | 80 | 100 | 115 | 125 | 140 | 150 | 155 | 165 |

### Nominal flow rate by extract air areas

| Room | | Nominal ventilation |
|---|---|---|
| Utility room 3) | m³/h | 20 |
| Basement room, e.g. recreational room 1) | m³/h | 20 |
| Dressing room 4) | m³/h | 20 |
| Toilet | m³/h | 20 |
| Bathroom | m³/h | 40 |
| Shower | m³/h | 40 |
| Pantry 5) | m³/h | 20 |
| Kitchen | m³/h | 40 |
| Sauna 2) | m³/h | 40 |

1) Heated and inside the thermal envelope.

2) A sauna must be treated in the same way at least as a bathroom. If significantly higher and regular moisture loads arise, e.g. through operation of a steam sauna, the required extract air flow rate must be calculated separately.

3) If washing is dried on an airer in the utility room, an extract air flow rate of 40 m³/h must be provided for.

4) Subject to structural conditions, dressing rooms may be designed as both an extract air area and a supply air area. Dressing rooms with a floor area of <5 m² are not ventilated. Dressing rooms are generally extract air areas.

5) Subject to structural conditions, pantries may be designed as both an extract air area and a supply air area. Pantries are generally extract air areas.

### Low extract air flow rate for large living space

In large loft apartments, for example, with a living space of 120 m² but a small kitchen and bathroom, the extract air flow rate is considerably lower than the supply air flow rate. In this case, the hallway can also be designed with an extract air flow rate of 20 m³/h.

### Transfer area

Transfer areas define the area between rooms of an apartment, where air flows from the supply air area to the extract air area. Appropriate measures must be taken to ensure that there is a transfer of air, e.g. by shortening the door leaves at the bottom of the door or by installing suitable ventilation grilles in doors or walls.

### Division of the supply air flow rate

The supply air flow rate is divided among the individual supply air areas based on the supply air factors per room.

# Air flow rate calculation (Germany)

### Example

The calculation example is based on the floor plans of a residential building with a living space of 150 m² over two floors.

### Nominal flow rate by area

| Nominal flow rate by area | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Living space | m² | 20 | 30 | 50 | 70 | 90 | 110 | 130 | **150** | 170 | 190 | 210 |
| Nominal ventilation | m³/h | 35 | 45 | 65 | 80 | 100 | 115 | 125 | **140** | 150 | 155 | 165 |

The floor area is 150 m², and the resulting nominal flow rate is 140 m³.

### Nominal flow rate by extract air areas

| Room | | Nominal ventilation |
|---|---|---|
| Utility room | m³/h | 20 |
| Pantry | m³/h | 20 |
| Bathroom | m³/h | 40 |
| Shower | m³/h | 40 |
| Kitchen | m³/h | 40 |
| **Total extract air** | **m³/h** | **160** |

The extract air flow rate is 160 m³.

The extract air flow rate is decisive for further planning, as it is higher than the nominal flow rate by area.

The same flow rate must be introduced into the building as the supply air flow rate.

### Division of the supply air flow rate

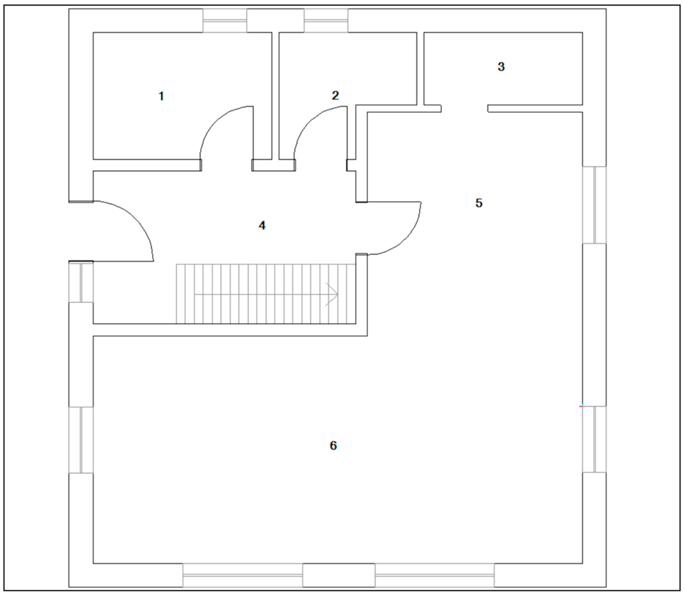
The supply air flow rate is divided proportionally among the supply air areas. Supply air factors are used for the calculation.

| Supply air factors | |
|---|---|
| Living | 3.0 (±0.5) |
| Dressing room | 1.5 (±1.0) |
| Bedroom | 2.0 (±1.0) |
| Children's room 1 | 2.0 (±1.0) |
| Children's room 2 | 2.0 (±1.0) |
| **Total** | **10,5** |

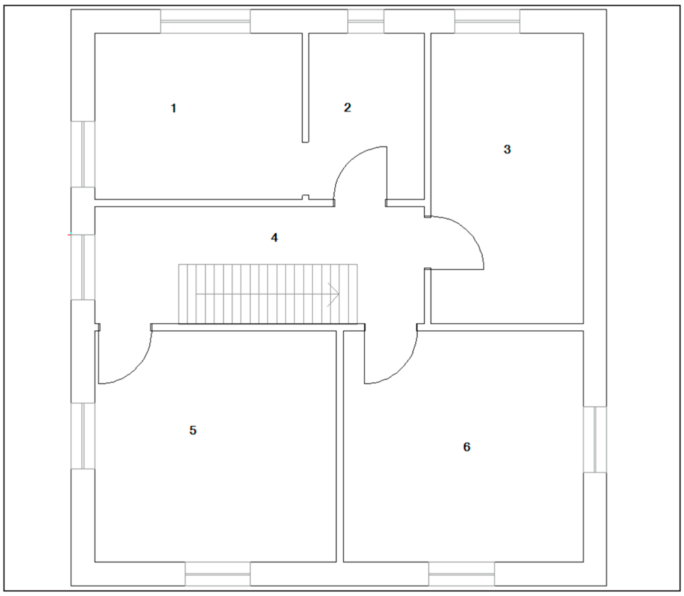
| Supply air division | Calculation | | Nominal ventilation |
|---|---|---|---|
| Living | 160 / 10.5 * 3.0 | m³/h | 45,7 |
| Dressing room | 160 / 10.5 * 1.5 | m³/h | 22,8 |
| Bedroom | 160 / 10.5 * 2.0 | m³/h | 30,5 |
| Children's room 1 | 160 / 10.5 * 2.0 | m³/h | 30,5 |
| Children's room 2 | 160 / 10.5 * 2.0 | m³/h | 30,5 |
| **Total** | | **m³/h** | **160** |

Supply air flow rate and extract air flow rate are the same and distributed among the rooms.

### Example of a floor plan




1 Utility room
2 Shower
3 Pantry
4 Air transfer in hallway
5 Kitchen
6 Living room




1 Bedroom
2 Dressing room
3 Bathroom
4 Air transfer in hallway
5 Children's room 1
6 Children's room 2

If the utility room has a door with an airtight seal, the room must be supplied with supply air and extract air.

# Positioning of vents

### Sizing and positioning of vents

The sizing and positioning of the supply air and extract air vents have a considerable impact on user convenience.

Greater air flow rate increases the pressure drop and flow velocity in the air duct and through air vents. This also means a rise in flow noise. The maximum flow rate per air vent can be used to derive the required number of air vents per room.

Supply air and extract air vents must be positioned so that the room has a good flow of air through it. To prevent draughts, air vents should not be installed directly above frequently used living spaces.

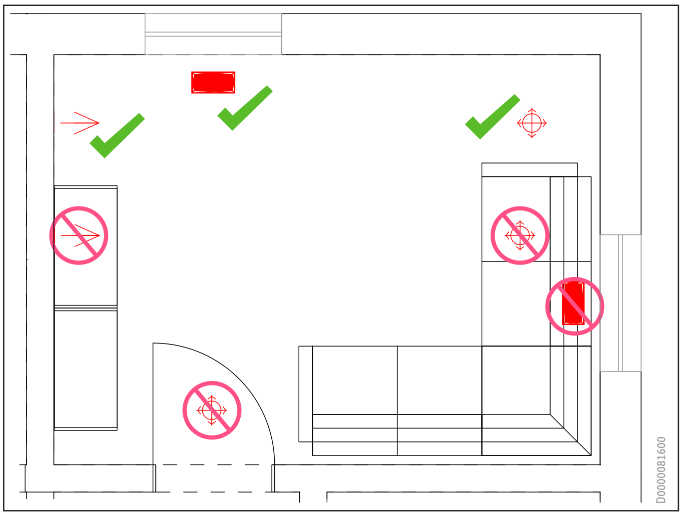
No air vents should be positioned over seating and resting areas in supply air areas or directly above showers in extract air areas.

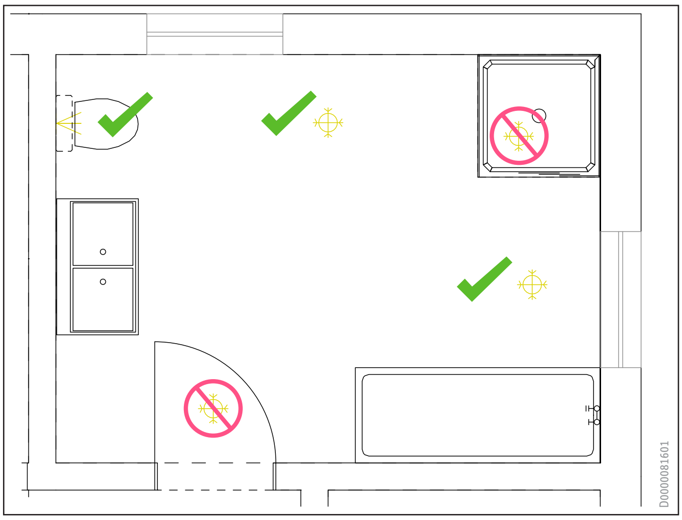
The extract air vent in the kitchen should have a clearance of approx. 2 m from the cooker and at least 60 cm from the walls.

In bedrooms and children's rooms, the supply air vents must not be positioned directly over the bed.

Air vents should not be routed through furniture or other objects.

### Positioning examples for vents





# Air routing systems

**Air routing with centralised ventilation**

Air is routed fully inside the thermal building envelope.

Air can also be routed outside the thermal building envelope if the air ducting has vapour diffusion-proof insulation.

**Air distribution**

The supply air and extract air is distributed either via a central distributor or via a distribution network.

**Routing in an unfinished floor/screed**

Round pipes are used for air routing.

Flexible flat ducts are used for air routing.

**Routing in suspended ceilings**

Flexible flat ducts are used for air routing.

Round pipes are used for air routing.

**Routing in concrete ceilings**

Round pipes are used for air routing.

**Stud walls**

Flexible flat ducts are used for air routing.

Round pipes are used for air routing.

**Wooden ceilings**

Flexible flat ducts are used for air routing.

Round pipes are used for air routing.

# Demand-based system - extract air side

**Demand-based system - extract air side**

A demand-based ventilation system ensures continuous mechanical ventilation with minimal air flow rate.

This is achieved using humidity-dependent extract air vents and pressure monitoring in the ventilation unit.

» Matching of extract air flow rates according to relative humidity through controlled extract air vents.

» Matching of supply air flow rates depending on the extract air flow rate with a pressure sensor in the extract air.

Lowering the air flow rate when air is dry also reduces the ventilation noise.

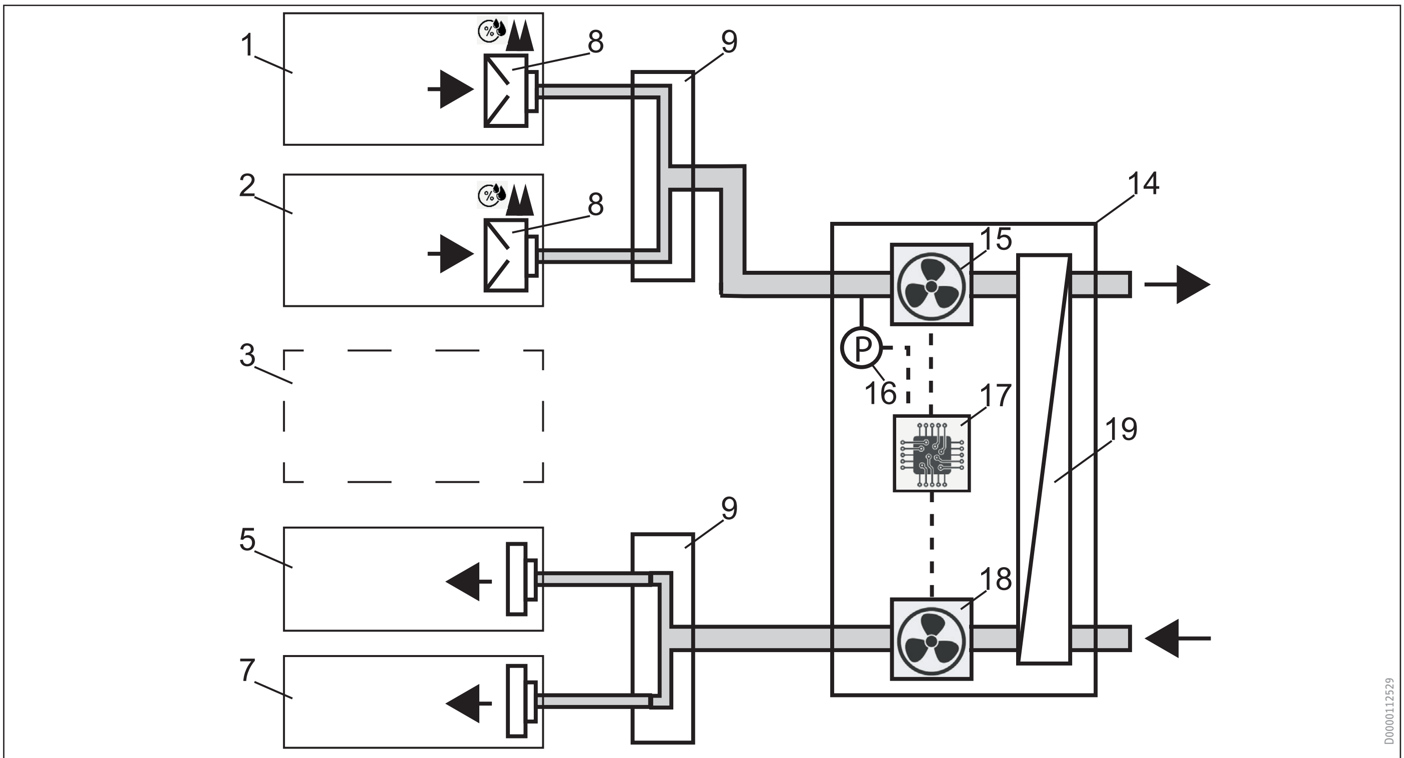
**Function**

Standard ventilation systems are operated with constant flow rate control. A flow rate is fixed and the ventilation unit keeps this rate constant, irrespective of pressure changes in the system.

The system includes constant pressure control with a pressure sensor in the extract air connector of the ventilation unit.

» If the indoor air is dry, the humidity-dependent vents close and the pressure in the ventilation system increases. The ventilation unit reduces the air flow rate until the set system pressure is reached again.

» If the indoor air is humid, the humidity-dependent vents open and the pressure in the ventilation system drops. The ventilation unit increases the air flow rate until the set system pressure is reached again.




1 Extract air area, e.g. bathroom
2 Extract air area, e.g. kitchen
3 Transfer area, e.g. hallway
4 Indoor air sensors, e.g. CO2 sensor, air quality sensor, presence sensor, occupant counter, humidity sensor
5 Supply air area, e.g. living room
6 Indoor air sensors
7 Supply air area, e.g. bedroom
8 Humidity-controlled extract air vent
9 Air distributors
10 Motor-controlled balancing valve
11 Air distributor with motor-controlled air vents
12 Control PCB
13 Motor-controlled air vent
14 Centralised ventilation unit
15 Extract air fan
16 Extract air pressure sensor
17 Control PCB
18 Supply air fan
19 Air-air heat exchanger

# Demand-based system - extract air and supply air

**Demand-based system - extract air and supply air**

A demand-dependent ventilation system ensures that air flow rates are matched to each space.

This is achieved with $CO_2$ and presence sensors, as well as humidity-controlled extract air vents.

» Matching of extract air flow rates according to relative humidity through controlled extract air vents.

» Matching of supply air flow rates subject to air quality in the rooms/areas captured with the relevant sensors.

» Compensation of the lower air flow rate in each case.

» Lowering the air flow rate when air is dry also reduces the ventilation noise.

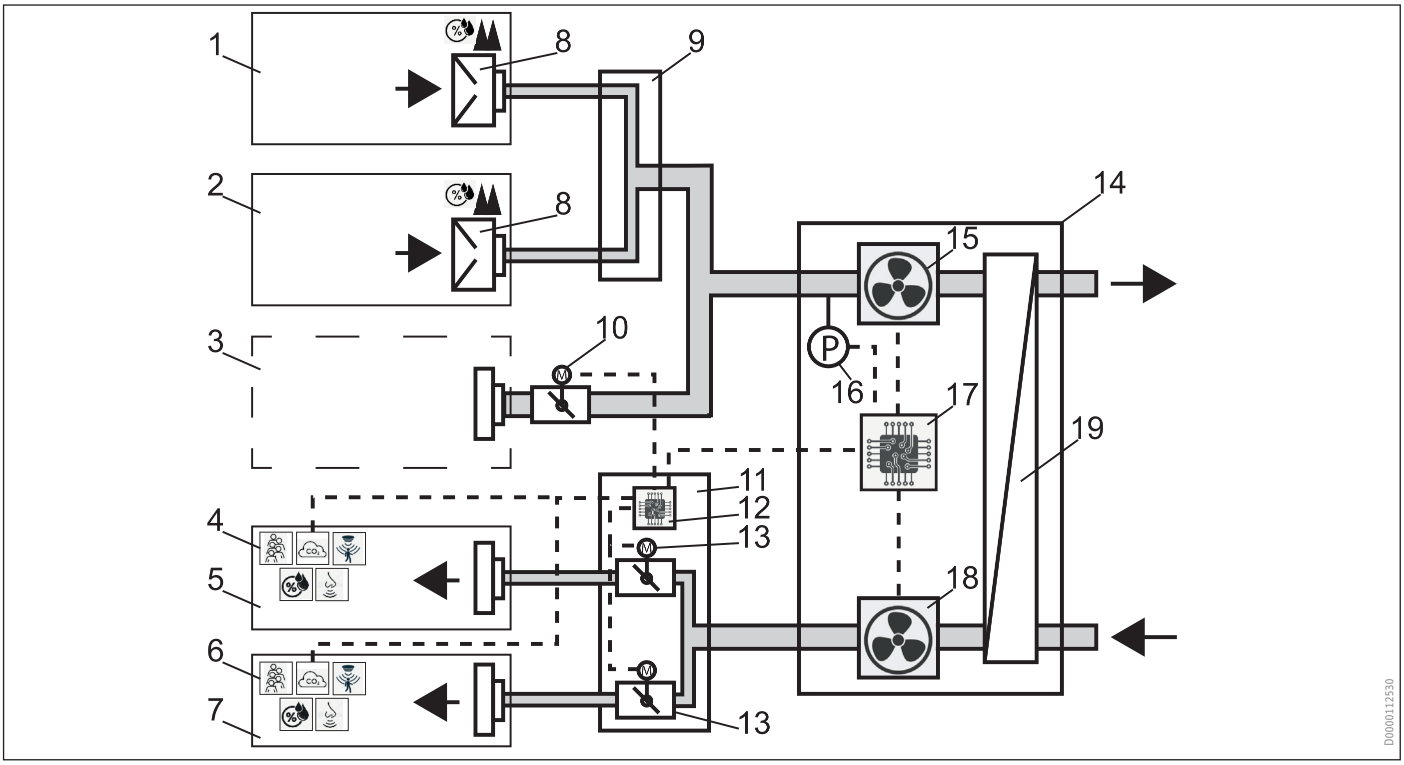
**Function**

Standard ventilation systems are operated with constant flow rate control. A fixed flow rate is set and the ventilation system keeps this constant, irrespective of pressure changes in the system or the indoor air quality.

With this ventilation system, sensor control ensures that the optimum air flow rate for each room is always achieved.

» If the indoor air is humid and a higher extract air flow rate is required, then the humidity-controlled extract air vents open automatically. The supply air flow rate is increased via sensor control and the supply air vents are opened further. This compensates for the higher extract air flow rate.

» If a higher air flow rate is required on the supply air side, then the compensation valve on the extract air side is opened. Compensation of uneven air flow rates on the supply air and extract air sides cannot be achieved via the standalone extract air vents.




1 Extract air area, e.g. bathroom
2 Extract air area, e.g. kitchen
3 Transfer area, utility room or hallway
4 Indoor air sensors, e.g. CO2 sensor, air quality sensor, presence sensor, occupant counter, humidity sensor
5 Supply air area, e.g. living room
6 Indoor air sensors
7 Supply air area, e.g. bedroom
8 Humidity-controlled extract air vent
9 Air distributors
10 Motor-controlled balancing valve
11 Air distributor with motor-controlled air vents
12 Control PCB
13 Motor-controlled air vent
14 Centralised ventilation unit
15 Extract air fan
16 Extract air pressure sensor
17 Control PCB
18 Supply air fan
19 Air-air heat exchanger

# General design of decentralised ventilation systems

**General design of ventilation systems**

Various country-specific standards, guidelines and specifications exist for the design of ventilation systems.

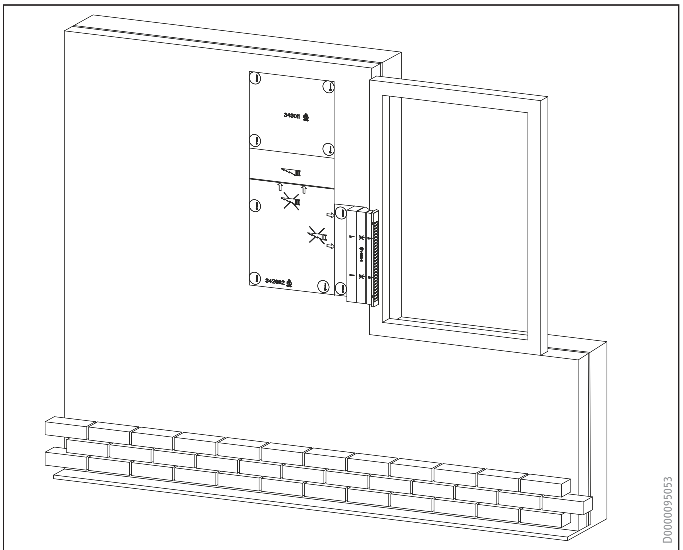
At this point, we will give a general overview of design aspects.

**Air routing with decentralised ventilation**

Air routing of decentralised ventilation systems occurs directly via the ventilation units installed in the external walls. Depending on the type, various internal and external panels may be used.

Air routing can also be achieved through special reveal ducts whereby air is routed above the window reveal. The air discharge grille should have a clearance of at least 3 cm from the window sill, for example to prevent condensate on the window sill. The air discharge grille must route any air flow away from the window.

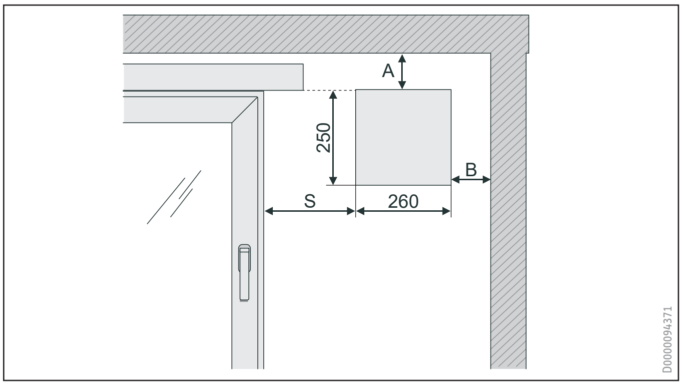
**Example illustration of a reveal duct**




**Minimum clearances including external panel**

- » The product-specific minimum clearance to the side of the internal panel must be observed.
- » In front of the internal panel, there must be sufficient free space to insert and remove the fan unit and any filters.
- » Appliances should not be positioned near seating areas or at the head of a bed.
- » Ensure the product-specific minimum clearance from all sides of the external panel to downpipes, balconies and other solid objects.
- » When reveal ducts are used on the external wall, the minimum distance between the window and thermal fan must be observed.

**Example illustration**



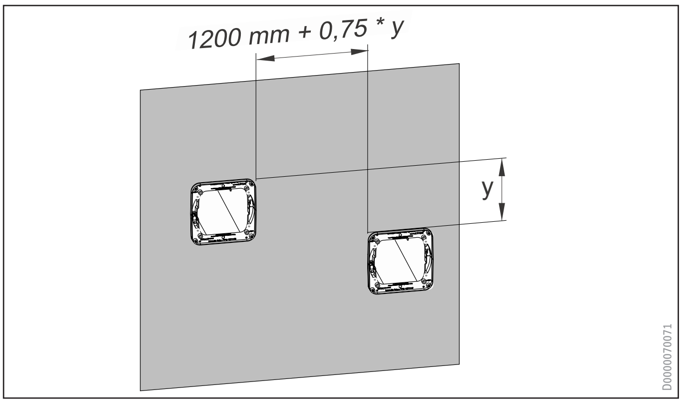

A Min. 100 mm
B Min. 100 mm
S Specified clearance depending on structural condition of wall

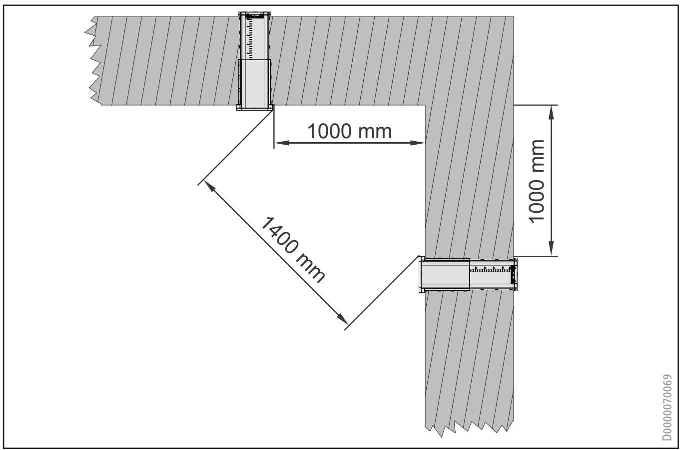
The upper edge of the internal panel should be positioned approx. 30 mm below the upper edge of the window.

**Clearances between appliances working in differential mode**

Appliances working as a pair in differential mode must be installed with a product-specific minimum horizontal and vertical clearance.

**Example illustration**



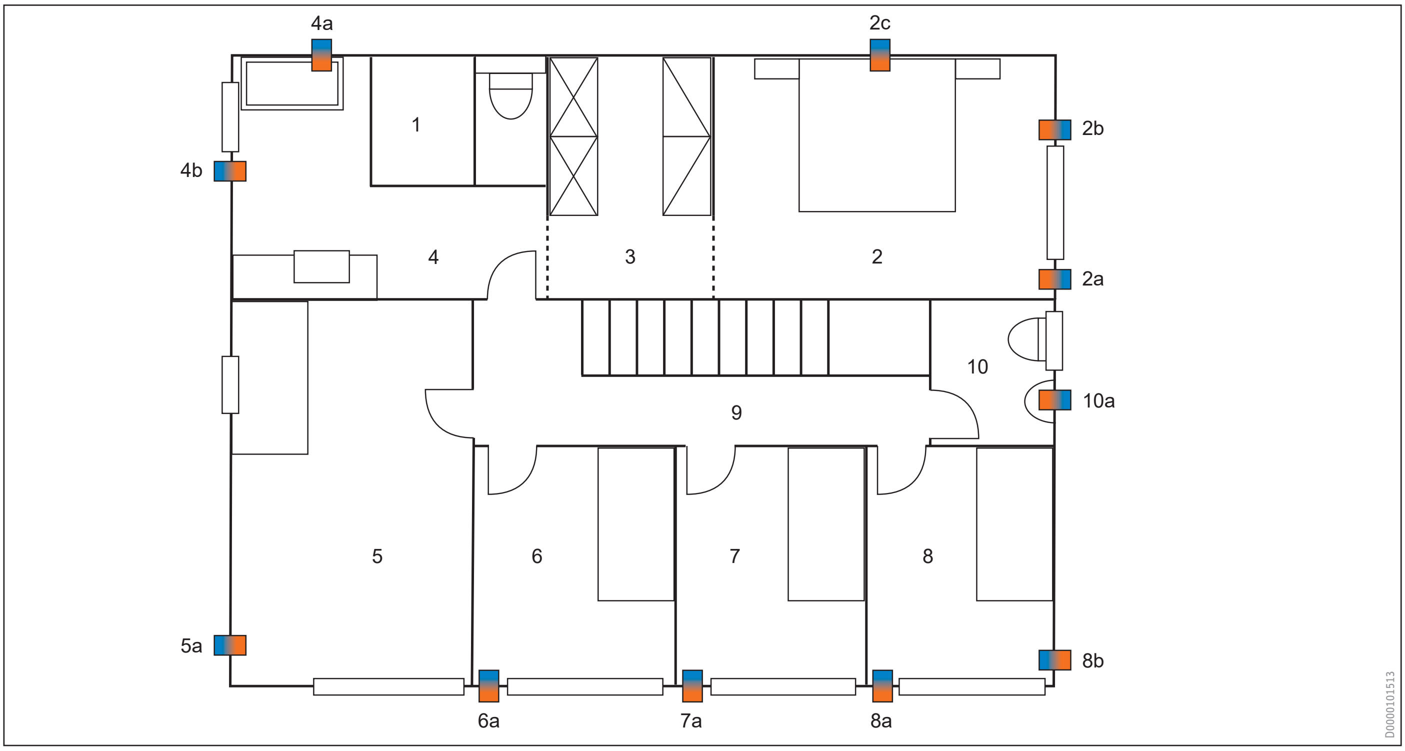



# Unit positioning

### Optimal unit positioning for comfort

The choice of unit positioning determines the comfort level within the living space. The illustrations below show various positioning examples in relation to the actual use of the rooms, as indicated by the furniture.

### First floor



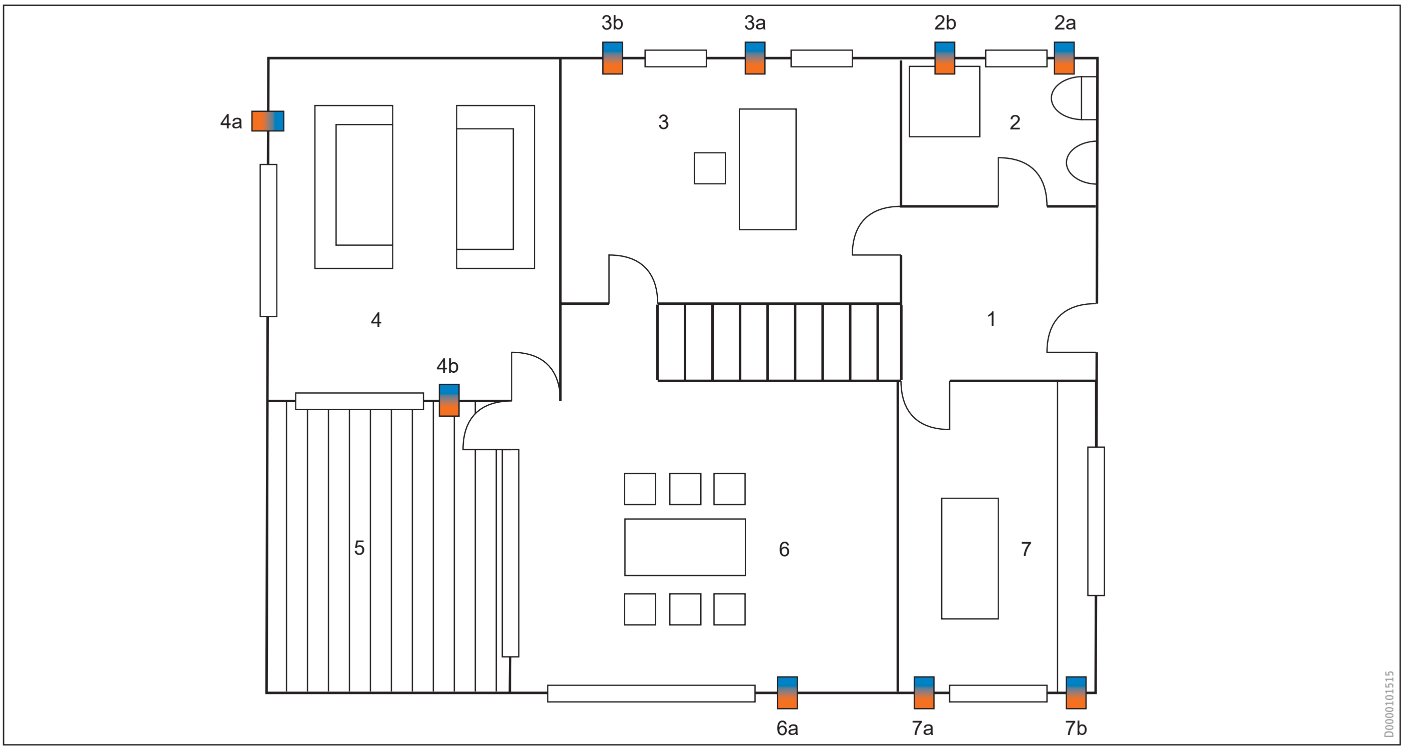

1 Sauna
2 Parents
3 Dressing room
4 Bathroom (extract air)
5 Guest room
6 Children's room 1
7 Children's room 2
8 Children's room 3
9 Hallway
10 Bathroom (extract air)

| Thermal fan | Comfort | Good | Not so good |
|---|---|---|---|
| 2a | high | next to a window, great distance from bed | |
| 2b | medium | next to a window | medium distance from bed |
| 2c | not recommended | | directly in a wall, close to the bed |
| 4a | not recommended | | right by the protection zone |
| 4b | high | next to a window, outside any protection zones | |
| 5a | high | diagonally opposite to the door, optimum cross flow, generous distance from bed | |
| 6a | high | next to a window, optically pleasing façade | |
| 7a | high | next to a window, optically pleasing façade | |
| 8a | high | next to a window, optically pleasing façade | |
| 8b | low | next to a window | unattractive on external façade, small distance to bed |
| 10a | high | next to a window | |

# Unit positioning

## Optimal unit positioning for comfort

### Ground floor




1 Entrance/porch
2 Bathroom (extract air)
3 Study
4 Living room
5 Terrace
6 Dining room
7 Kitchen (extract air)

| Thermal fan | Comfort | Good | Not so good |
|---|---|---|---|
| 2a | high | next to a window, outside any protection zones | |
| 2b | not recommended | | right by the protection zone |
| 3a | high | next to a window, even flow-through | |
| 3b | low | next to a window | uneven flow-through |
| 4a | high | diagonally opposite to the door, optimum cross flow | |
| 4b | low | next to a window | close to a door |
| 6a | high | diagonally opposite to the door, optimum cross flow | |
| 7a | high | next to a window, positioned away from the kitchen units | |
| 7b | high | next to a window | not positioned away from the kitchen units |

**Bathroom**

With internal bathrooms, air must be routed inside the building via air ducts.

For the duration of occupancy in a bathroom with window, the unit must operate as an extract air fan. For this, the unit is taken out of standard differential mode and returned back to differential mode once occupancy has ended.

There are several options for starting extract air mode.

The extract air demand function can be implemented via existing light switches or with a humidity sensor.

Through the control unit, a switch-over delay and a run-on time can be set.

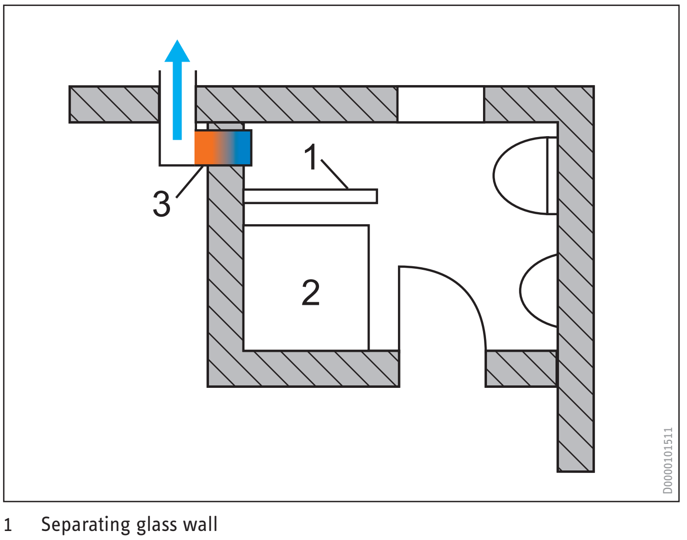
The system is patented in Germany (DE 10 2014 100 109 A1).

**Installation in a bathroom**

Always observe the protection zones when installing a unit in a bathroom.

If the protection zones prevent installation, ventilation can also occur via a neighbouring room. Reveal ducts can be used for this.

Permissible installation sites can also be created by additionally fitting glass separation walls or similar between shower and fan. To ensure compliance with the protection zone, the installation height of the fan must be compatible with the height of the glass wall.

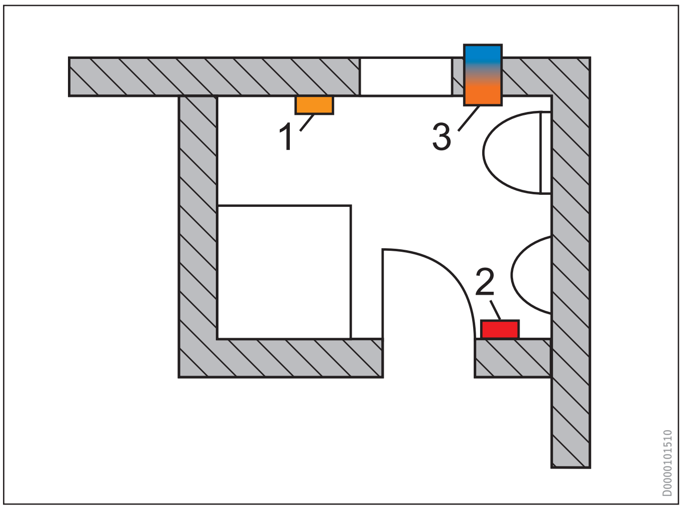



1 Separating glass wall
2 Shower
3 Thermal fan

**Control**

A humidity sensor regulates the unit.

We recommend an additional, demand-dependent fan for removing odours.




1 Humidity sensor
2 Pushbutton activation with run-on time
3 Thermal fan

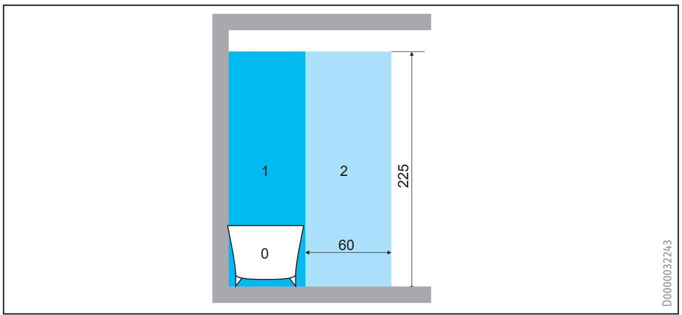
**Bathrooms without windows**

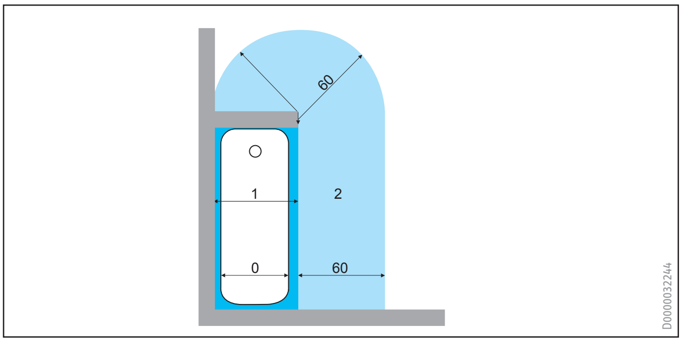
A thermal fan should not be used in bathrooms without windows. In windowless bathrooms, use an extract air fan with demand-dependent control.

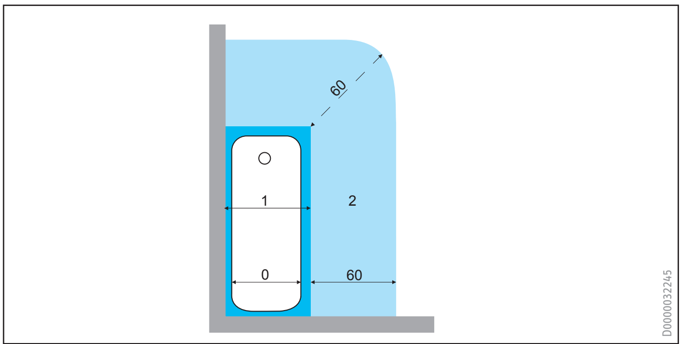
# Bathroom

**Safety zones in bathrooms**

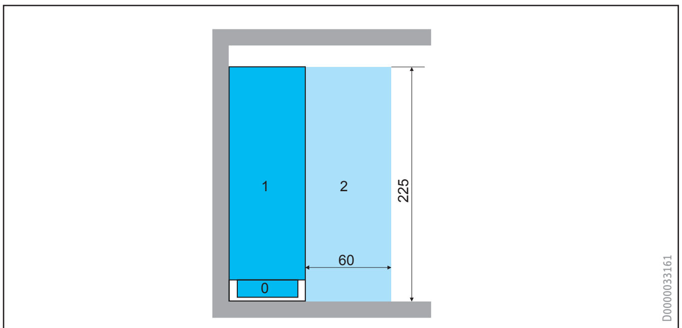
In accordance with the applicable protection rating, the appliance may only be installed outside protection zones 1 and 2.



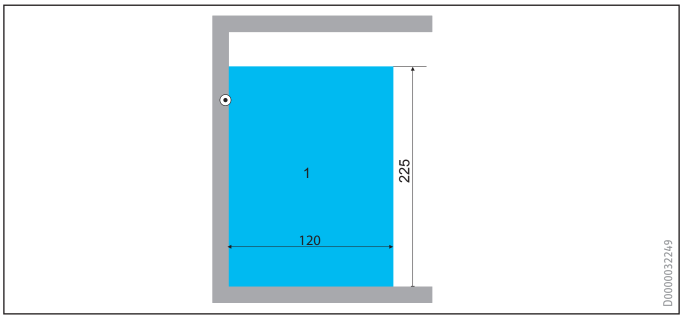




Side view, shower

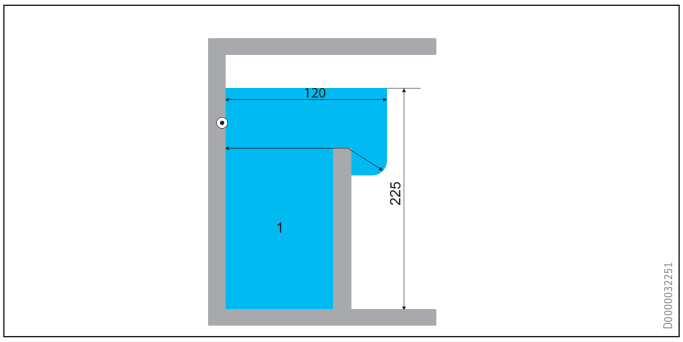



Dimensions of zone 1 in rooms with shower but without bath tub

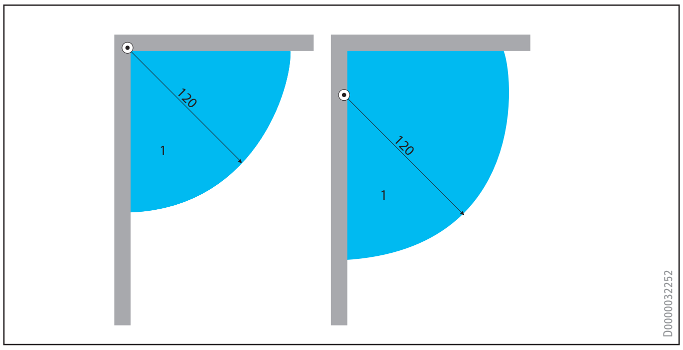
Side view



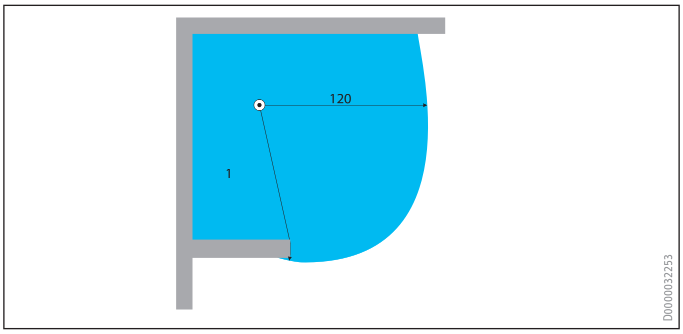

Side view with permanently fitted partition and clearance for overreach




Plan view with alternate water outlet points




Plan view with permanently fitted partition and clearance for reach-round




All dimensions in cm

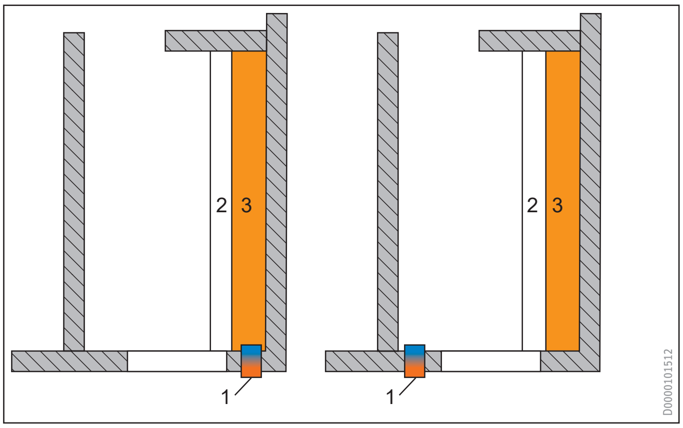
⦿ Permanently installed water outlet

# Kitchen

**Installation in a kitchen**

When designing the layout, bear in mind that kitchen fittings are generally not marked on the construction plans. In particular, take into account the subsequent position of wall cupboards.

**Example "wrong/right"**




1 Thermal fan
2 Working area
3 Wall cupboards

**Basement ventilation**

For controlled ventilation of one or more basement rooms with minimal or no heating, a special basement fan or a fan with a special control concept must be used.

Special basement fans or fans with basement control are designed for this application.

Basement fans often have integral sensor technology, which measures temperatures and humidity. Based on the measured values, both the air flow rate and the air direction are automatically matched.

# Other influencing appliances in the building

**Tumble dryers**

Extract air tumble dryers can not be used. The air flow rate is significantly higher than the air flow rate of a ventilation system. The ventilation system's even air flow is increased by an extract air tumble dryer.

Extract air tumble dryers expel indoor air outdoors without heat recovery and are therefore no longer practical in terms of energy efficiency.

**Kitchen extractor hoods**

Kitchen extractor hoods must be used purely as air recirculating units.

Never connect a kitchen extractor hood to a ventilation system.

Irrespective of the ventilation system used, an air recirculation extractor hood must be installed. Air recirculation extractor hoods do not impair the function of the ventilation system, as they are pressure-neutral. They filter air and, depending on the model, can also remove odours efficiently.

However, if an exhaust air extractor hood is installed, an inflow of fresh air must be ensured.

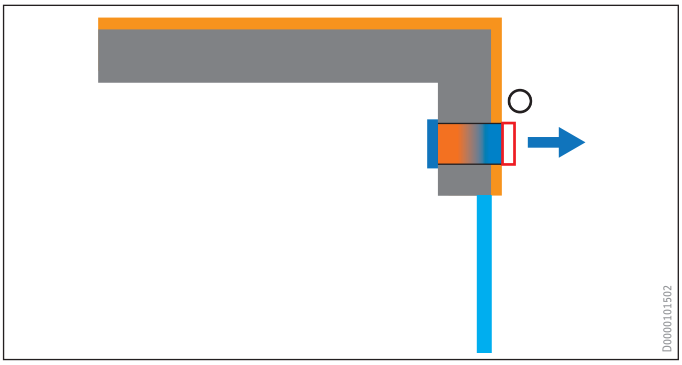
Kitchen extractor hoods expel indoor air outdoors without heat recovery and are therefore no longer practical in terms of energy efficiency.

A ventilation system cannot replace an extractor hood. Extractor hoods have significantly higher air flow rates than the entire ventilation system in the building.

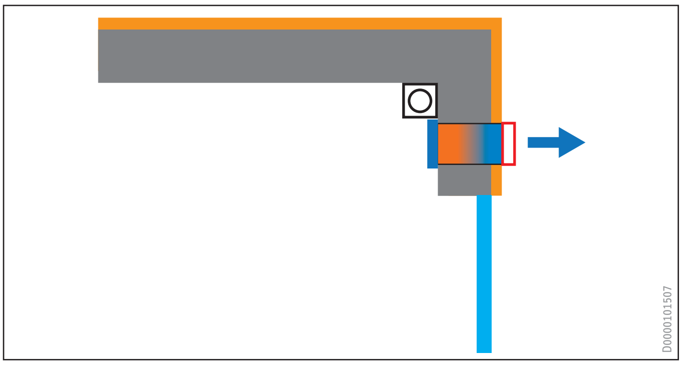
# Positioning errors

**Positioning errors**

When designing the system layout, bear in mind that rainwater drainpipes may not yet have been marked on the building plans.

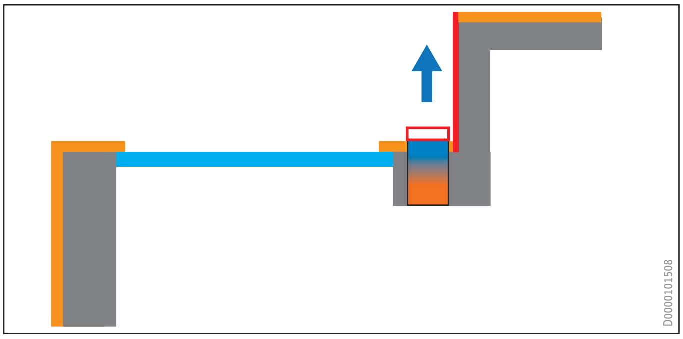


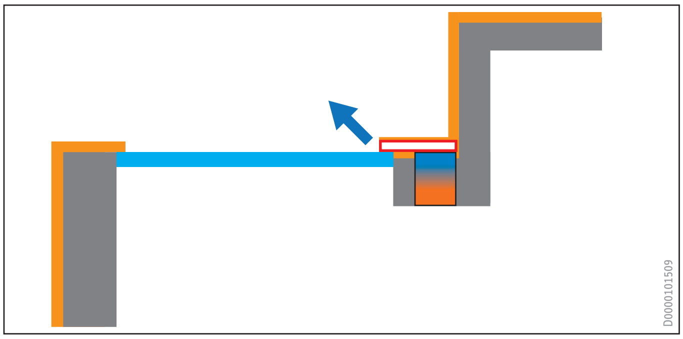

When designing the system layout, bear in mind that shafts in room corners may not yet have been marked on the building plans.




Avoid positioning the units in locations where the air flow is restricted on one side, e.g. near balconies. If necessary, use a reveal duct to redirect the air flow to an unrestricted location.

This also applies if the external wall terminal cannot be mounted in the intended location.



**Standard-compliant ventilation in Germany**

Where possible, operate the units in pairs.

An uneven number of units may also be implemented with appropriate planning and installation.

The unit pairs can be installed for a single room as well as a group of rooms.

We recommend installing the units as far away from each other as possible. Within a residential unit, multi storey allocation is also possible. Ensure that air can stream between the rooms through sufficiently sized overflow apertures, e.g. door undercuts.

In extract air mode, condensate can form in the heat exchanger at low outside temperatures. This condensate is reabsorbed when the air stream changes direction, which counteracts excessive dehumidification of the indoor air.

## Fire safety

### Basic requirements

The basic requirement of fire safety is to prevent the spread of fire and smoke to other fire sections within the building, such as other floors, staircases or escape and rescue routes.

As ventilation systems are of particular significance with regard to the spread of fire and smoke, fire safety deserves special attention.

Fire safety requirements vary depending on the region and state and must therefore be clearly specified.

**Discretion of the flue gas inspector**

It is advisable to involve the relevant local flue gas inspector in the building design process to comply with local and regional requirements.

**Operation of the appliance in buildings with combustion equipment**

If the building contains combustion equipment (tiled stoves, fireplaces, etc.), the responsible flue gas inspector must be consulted at the design stage. The flue gas inspector assesses whether all statutory regulations are observed. Here, a differentiation is made between room sealed and open flue combustion equipment.

For simultaneous operation of combustion equipment and a mechanical ventilation system, we recommend choosing approved room sealed combustion equipment (in Germany, with DIBt approval).

**Room sealed combustion equipment**

In conjunction with room sealed combustion equipment, no additional precautions are generally required. Assessment is carried out by the flue gas inspector.

**Open flue combustion equipment**

**WARNING Injury**
**If open flue combustion equipment is operated with the mechanical ventilation system, tested safety equipment must be installed. The combustion equipment must also have a separate combustion air supply.**

With open flue combustion equipment, a differentiation must be made between alternate and simultaneous operation of the ventilation system and combustion equipment.

**Alternate operation**

Alternate operation means that, when the combustion equipment is commissioned, the mechanical ventilation system is switched off or cannot be started.

**Simultaneous operation**

**WARNING Injury**
**To prevent any flue gas escaping into the installation room, it is necessary to ensure that sufficient combustion air is supplied or that the negative pressure in rooms where the stove/fireplace is installed is not greater than 4 Pa. Tested safety equipment must be installed to monitor the chimney draught (differential pressure monitoring) and to switch off the ventilation unit in the event of a fault.**

▶ Install the safety equipment in such a way that it interrupts the appliance power supply when required.

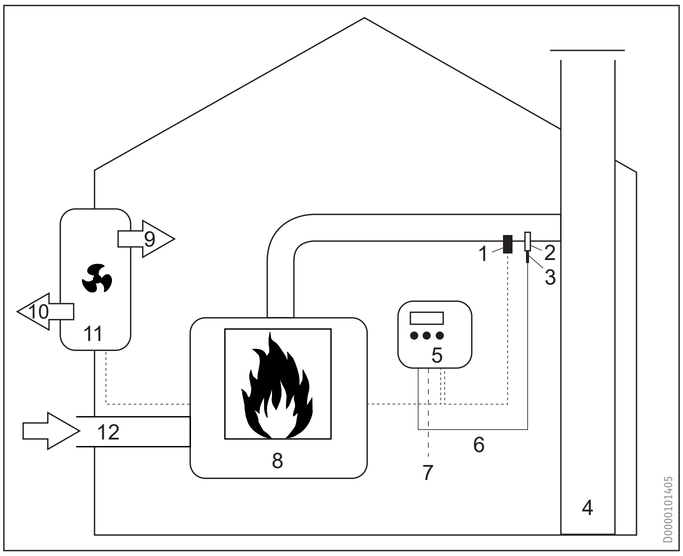
The equipment for differential pressure monitoring should fulfil the following requirements:

» Monitoring of the differential pressure between the connection piece to the chimney and the combustion equipment installation room
» Possibility of matching the shutdown value for the differential pressure to the minimum draught requirement for the combustion equipment
» Floating contact to switch off the ventilation function
» Optional connection of a temperature capturing device so that differential pressure monitoring is only enabled when the combustion equipment is in operation and so that unwanted shutdowns due to environmental influences can be prevented

**Notice**
Differential pressure switches that use the pressure differential between the outdoor air pressure and the pressure in the combustion equipment installation room as a response criterion are not suitable.

**Combustion equipment safety pressure switch**

Due to possible pressure fluctuations, e.g. in the flue, a temperature sensor must always be integrated into the safety chain. Without temperature sensor, the ventilation would switch off at every pressure fluctuation.




1 Temperature sensors
2 Pressure measuring adaptor
3 Pressure measuring tube
4 Chimney
5 Temperature and differential pressure monitoring
6 Silicone hose
7 Installation room pressure measuring site
8 Open flue combustion equipment
9 Supply air
10 Exhaust air
11 Ventilation unit
12 Separate combustion air supply direct into the combustion chamber (cross-section according to manufacturer's information)

# Notes

# Centralised ventilation systems

**General**

- Incorrectly sized ventilation unit, which causes excessively high power consumption.
- Incorrectly sized ventilation unit, which causes excessively low or high air change.
- Incorrectly sized air distribution system and/or inlets/outlets, which cause flow noise and lead to higher power consumption and an increased sound level due to an excessive pressure drop.
- Not all areas were included in the ventilation system design, meaning that building damage may occur.
- A garage was included in the ventilation system design for the living spaces. Garages must have a separate ventilation system. If there is a connecting door from the utility room to the garage, it is necessary to ensure that the door is permanently closed, or when opening the door, the ventilation system is switched off via a contact switch. Exhaust must not penetrate living spaces.
- Incorrectly positioned air inlets and outlets, which cause draughts and/or discolouration (dirt) on a nearby wall or the surrounding ceiling.
- Assignment of supply air and extract air incorrectly defined. A "guest room", which typically receives "supply air", can also be utilised as a "fitness room", which must be connected to extract air.
- Error in the room/area air flow rate calculation.
- Excessively high flow velocities in the air distribution system, noticeable, for example, in a high level of noise in bedrooms.
- Silencers and/or crosstalk silencers and/or minimum pipe lengths not taken into account.
- Wall or ceiling openings designed for air ducting are too small.
- Unfavourable positioning of vertical air ducting and pipe dimensions underestimated.
- Insufficient thermal insulation for air ducting in external walls, meaning that condensate and building damage may occur.
- Insufficient clearances of the air distribution system in screed or unfinished concrete, which could lead to structural weakness of the building.
- Outdoor air is drawn from a shaft, which is not permitted and may have health implications.
- Combi grille for exhaust air and outdoor air positioned against the main wind direction, meaning that odours from the exhaust air could get into the building.
- Insufficient distance between exhaust air and outdoor air grilles.
- Failure to comply with fire safety regulations.
- Failure to comply with specifications regarding operation of a fireplace.
- No approval by flue gas inspector.

# Decentralised ventilation systems

**General**

- Not all rooms were incorporated into the ventilation concept, meaning that building damage could occur.
- A garage was included in the ventilation system design for the living spaces.
- Incorrectly positioned air inlets and outlets, which cause draughts.
- Too much or too little air for rooms in the design.
- Incorrect design of internal or external panels, resulting in increased noise pollution.
- Ventilation unit or relevant electrical components included in electrical protected zone.
- Incorrectly positioned air inlets and outlets, which cause draughts and/or discolouration (dirt) on a nearby wall or the surrounding ceiling.
- Minimum clearances of external wall outlets to walls, ceilings and windows not observed
- Failure to comply with fire safety regulations.
- Failure to comply with specifications regarding operation of a fireplace.
- No approval by flue gas inspector.
- Influence of main wind direction not taken into account.
- Influence of external noise not taken into account.
- Position of rain downpipes and supply shafts in the building not taken into account.
- Position of built-in furniture not taken into account, e.g. kitchen wall cupboards.
- Position of window and door lintels not taken into account.
- Curtains, roller blinds, net curtains and venetian blinds not taken into account.

**Thermal fan**

- Wall structure not checked. Ventilation system not suitable for the existing wall structure. Pipes or supporting beams in the wall.
- Incorrect appliance designed for the available wall thickness. Minimum/maximum wall thickness not taken into account.
- Wall outlets too small for the existing appliances.
- Wall outlets positioned incorrectly, falling below the minimum clearances from ceilings and walls.
- Incorrect appliance positioning, e.g. at the head of a bed or too low down.
- If a thermal fan is positioned with insufficient clearance from the next window wall, the minimum dimension of the reveal duct width is underestimated, preventing the reveal duct from being installed.
- Reveal duct grille positioned too low down, meaning that the vertical clearance from the window sill falls below the minimum value. This leads to the formation of condensate or ice on the window sill.
- Cross air function designed incorrectly. Example: The combined kitchen/living room has been designed as a supply air area, allowing odours to penetrate the living space.
- Cross air function designed incorrectly. Example: Bedrooms should always be designed as supply air areas.
- Bathroom with a thermal fan designed without separate control.
- Reveal duct not matched to window and blind dimensions.
- Control concept not included in the design.

**Extractors with decentralised supply air**

- Undersizing of airflow apertures in external wall.
- Incorrect positioning of airflow apertures, leading to cold draughts.

## Centralised ventilation systems

- Insufficient clearances of the air distribution system in screed or unfinished concrete, which could lead to structural weakness of the building.
- Outdoor air intake and exhaust air routing without diffusion-proof insulation, which can result in condensate and subsequently in building damage.
- Incorrectly set or missing control parameters, leading to higher power consumption, e.g. deactivated automatic summer/winter mode changeover.
- Inadequate or no instruction given to operators of the ventilation system, which may lead to higher electricity costs, building damage and health problems as a result of incorrect operation.
- Unsuitable air vents without a seal ring, causing discolouration (dirt) on a nearby wall or the surrounding ceiling.
- Wall and ceiling outlets for air ducting too small.
- Air routing components, e.g. pipes and fixings, not isolated from building structure with structure-borne sound insulation, which leads to an increased sound level.
- Flexible connection pieces for connecting the ventilation unit to the air duct system not installed correctly.
- Condensate drain pipe installed incorrectly.

# Decentralised ventilation systems

**General**

- Delayed maintenance of filter and appliances, which could lead at least to a low air flow rate, higher electricity costs, building damage and health problems.
- Incorrect wiring or appliance connection, so that the thermal fans do not interact as designed.
- Incorrect internal or external panels installed, resulting in higher noise pollution.
- Ventilation unit or electrical components installed in electrical protected zone.
- Incorrectly set or missing control parameters, leading to higher power consumption, e.g. deactivated automatic summer/winter mode changeover.
- Inadequate or no instruction given to operators of the ventilation system, which may lead to higher electricity costs, building damage and health problems as a result of incorrect operation.
- Non-compliance with the specifications of the flue gas inspector.
- Doors to transfer areas have an airtight seal or no door undercut, preventing the air from flowing between rooms/areas.
- Retrofitted kitchen extractor hood causing disruption to the designed controlled ventilation.

**Thermal fan**

- Core holes or wall outlets do not have a fall. Condensate moisture must be able to drain from the ducts to the outside in order to avoid building damage.
- Appliance and external panel installed incorrectly, meaning that condensate does not drain correctly to the outside or could get into the building's thermal envelope.
- Reveal duct grilles installed the wrong way round, meaning that air is discharged onto the window pane instead of outdoors.
- External terminal of the telescopic duct not flush with the finished external wall (depending on product).
- Internal termination of the telescopic duct not flush with the finished internal wall (depending on product).
- Fan unit not installed correctly or not moved to the end position. This could cause condensate to form in the telescopic duct.
- External panel not fitted correctly or not secured correctly. Risk of injury from it falling.
- External panel fitted without a gasket. Water run marks may occur.
- Internal panel not open, so no ventilation can occur.
- Thermal fan switched off manually, meaning that controlled ventilation does not occur and this could result in building damage or health problems.
- Additional fly screens fitted to the appliances or external panels, leading to an insufficient air flow rate.
- Reveal duct not matched to window and blind dimensions.

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