housewarming

Guides

Draughts and Ventilation

Low Carbon Oxford North

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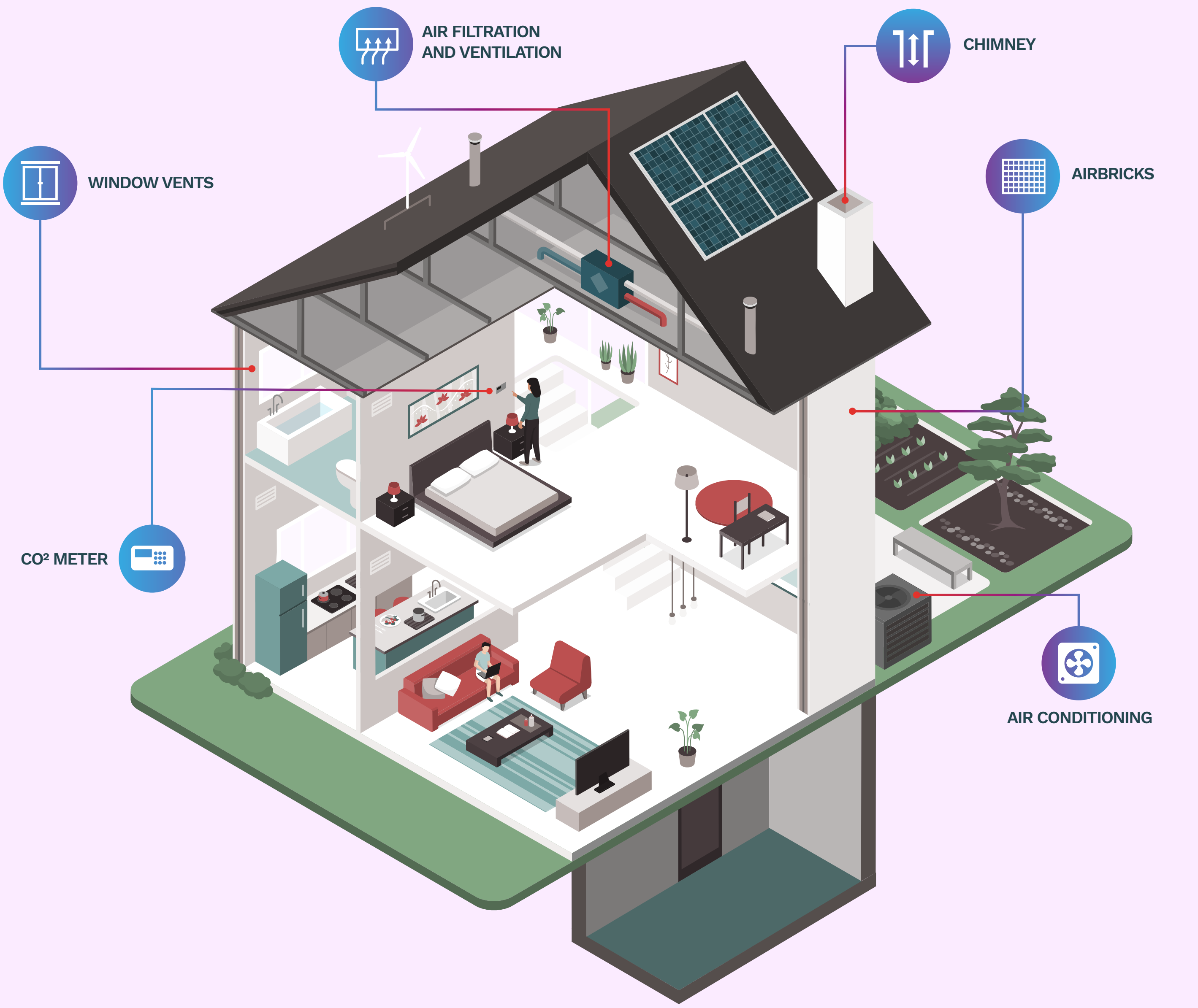

Low Carbon Oxford North

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WELCOME TO OUR FOURTH HOUSEWARMING GUIDE

This is the fourth in our series of Housewarming guides created by Low Carbon Oxford North. The series focusses on each of the core retrofit areas that may be required to improve the fabric of our buildings - fundamental to cutting energy use and the associated carbon emissions.

Stopping heat loss from our homes is also an essential step in moving away from fossil fuels and becoming heat pump ready, particularly for older homes. Our homes will become warmer, healthier, and more comfortable to live in too.

In this guide we focus on ventilation, draughts and airtightness. It is vital to have good air quality inside your home. It is also essential for safety that any room with a combustion device has adequate ventilation or there is a risk of carbon monoxide poisoning. These might include a fireplace, stove, gas cooker or open gas fire.

Cold wintry draughts are unpleasant though and excessive ventilation leads to high fuel bills. In fact, draughts and general 'air changes' may account for 50% or more of the heat loss from your home. Sealing up unwanted gaps in the fabric and windows keeps out this cold air. However, a minimum amount of controlled 'good' ventilation is necessary. Reducing draughts whilst ensuring good air quality needs to be balanced.

We recommend homeowners take professional advice at each stage of the retrofitting process. Our guides are intended as a support - to explain the main elements, measures and choices involved in each retrofit area and to provide knowledge to enable you to have better conversations with whichever professionals you choose to work with. The guides cover basic definitions and provide frameworks to help you weigh up the many options and decisions required.

There are many ventilation factors to consider.

VENTILATION AND AIR QUALITY

All houses have some holes and gaps which let air in and out regardless of whether you have closed all the windows and doors. Even the fabric of the building is slightly porous. So, a background level of natural ventilation occurs continuously in every home. Each house will have a different background level, regardless of age or similarity of build. New houses must meet a minimum standard.

Depending on the weather conditions the amount of air naturally filtering through all the holes and gaps in a house will vary. In winter gales it is not uncommon for the letter flap to rattle and whine, cold draughts rush across the floor and up the chimney chilling our feet and we wake up with a stiff neck after sleeping in a draught. Less obvious is that during a very cold, still, frosty night warm air is rising out of holes at the top of the house to be replaced with cold air leaking in at the bottom.

A draughty house will tend to have good internal air quality but high heating bills. Conversely, an airtight house can have poor internal air quality, if ventilation is not managed, but should have lower heating bills.

The number of people that use the house has an impact on air quality: a large four-bedroomed family home with only one person living there requires far less ventilation than a small three-bedroomed house with six people in residence mostly working from home. An active household that has many showers and enjoys home cooking every day will also need more ventilation. So a balance needs to be found between reducing draughts which cost us a lot in energy bills and ensuring enough air flow for good air quality.

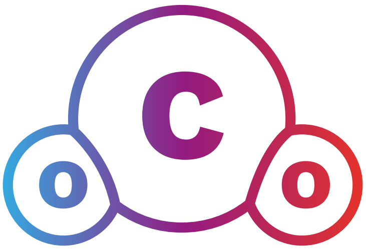
Fresh air is essential for good physical and mental health. Most of you will have experienced drowsiness or a headache after a long meeting in a stuffy room. A walk around the block soon refreshes. If you have combustion devices in your home such as a gas cooker or wood stove it is vital to have the right amount of ventilation.

Outside, traffic pollution, low-level ozone and high pollen levels affect air quality and health. Inside a closed building space there are more factors that degrade the air.

Examples include:

- **A build-up of carbon dioxide, CO_2**

  Simply having several people breathing in a room increases CO_2, although cooking, especially with gas, will increase it much more. Very high levels of CO_2 indoors are toxic but you are unlikely to reach that level unless there is no ventilation at all in a crowded room. This is the same CO_2 gas that is a major contributor to global warming, though the global outdoor levels that are of concern are very much below toxicity.



Carbon Dioxide / CO_2

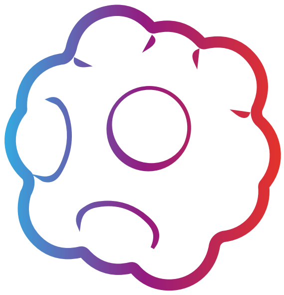
- **High Humidity**

  We breathe out moisture, humidity increases significantly with showers, baths, drying clothes indoors and long periods of cooking (to minimise, keep the lids on your pans). High levels of humidity feel oppressive and lead to condensation and mould which can be damaging to health.

Humidity / H_2O

- **Volatile Organic Compounds (VOCs)**

  These are emitted from many man-made materials including clothes, paint and carpets (that 'new-car' smell) and can be toxic as concentrations rise. Health effects may include eye, nose and throat irritation, headaches, loss of coordination and nausea if levels are high.



VOCs / Volatile Organic Compounds

Within a home generally all three of these (and other poor air contributors) tend to rise together. If one measure is too high, the others are likely to be high too.

MEASURING AND CONTROLLING AIR QUALITY

We may be aware of some parts of a house being damp or stuffy or smelling stale. This is an indication of too little ventilation. Conversely, if you can smell the diesel refuse truck that has just driven past this implies a draughty house.

For a more scientific measure, a simple hand-held or wall mounted CO_2 meter is a good way of getting a sense of indoor air quality. You simply place this in the room where you want to check air quality, switch it on and leave it for a few minutes (according to its instructions). These meters usually measure the amount of CO_2 in parts per million (ppm). Outdoor air has a CO_2 level around 400 to 450ppm depending on exactly where you are. Levels above 2,000ppm are harmful to health so must be avoided.

It is also possible to measure humidity with a simple sensor and humidity is often included in a CO_2 monitor. Remember, however, that your indoor measurements will be affected by outdoor humidity which varies according to the type of weather. In cold frosty weather typical of high pressure over the UK with a wind from the northeast there will be low humidity, whereas a warm front from the west under a low-pressure area brings rain which will have high humidity. This means any problem may not be due solely to poor inside ventilation. This is not the case with CO_2, so that is a better, more consistent measure.

A CO_2 meter – air quality OK

Air Quality Standards

There is no UK standard defining 'good' indoor air quality at home.

The UK Department for Education and Skills document BB101: Guidelines on Ventilation, Indoor Air Quality and Thermal Comfort in Schools requires that mechanical ventilation units meet a daily average CO_2 concentration of 1,000 ppm or lower. Finland, Norway, Denmark, Holland, Belgium and Germany all set a maximum CO_2 concentration in classrooms of 1,000 ppm, and France has reduced this limit to 900 ppm.

A 2016 study by Harvard University of office workers found thinking was adversely affected with levels of CO_2 above 1,000 ppm. REHVA (The Federation of European Heating, Ventilation and Air Conditioning Associations) says 600 to 800ppm is 'reliable indoor air quality' and this is supported by research.

The closest document to a standard for indoor air quality in the UK is The Building Regulations Part F Ventilation. This doesn't discuss air quality itself but specifies the ventilation rates for different rooms using extractor fans, minimum background rates from airbricks and trickle vents and allowable values for airtightness for new builds. Unfortunately, it uses a confusing mix of units and descriptions, and so professional help may be needed in some cases.

For example, a bathroom extractor fan must extract air at a rate of at least 15 litres/second if used intermittently and the total ventilation area of airbricks and trickle vents for an 'airtight' 75m² new build house with 3 bedrooms must be 50,000mm² (roughly equivalent to ~4 airbricks in total). Keeping humidity below about 70% and varying it is also noted in the research as important to keep mould at bay.

SIGNS THAT VENTILATION NEEDS INCREASING

Ventilation needs to be increased if:

- **You are feeling drowsy and lethargic**

  The main short-term sign of lack of ventilation is that the room seems 'stuffy' and people start to feel drowsy and lethargic. Using a portable CO_2 monitor may well show the CO_2 level has risen to over 1,500ppm. This should not be confused with similar symptoms of CO poisoning in a room with a combustion device which is not adequately ventilated. See box overleaf.

- **Your CO_2 measure is persistently higher than guidelines**

  If the CO_2 level is close to the outdoor air level of 450ppm the house is very well ventilated. This is good in summer, but in winter will lead to high heating bills. If the level is around 1500ppm continuously then there is a problem, but published research suggests the occasional ‘blip’ to that level is probably acceptable. A good aim for inside a house is something between 600 and 1,000 ppm of CO_2 in occupied rooms.

To keep CO_2 at 1,000ppm or less in a home with typical occupancy requires about 6 to 8 litres/second of fresh air which is 20m³ to 30 m³ per hour of ventilation. Various standards organisations recommend between 0.35 and 1 air changes per hour. One air change per hour means the whole air volume in a room is replaced each hour; about 30m² per hour – a lot of air to heat on a cold day!

These volume flows are difficult to envisage and depend on how many people are in the room and its size; a large room with only one person reading a book needs much less ventilation than a small room with the whole family doing aerobics! In The Building Regulations Part F there are guidelines as to the area of ventilation holes, extractor fan performance and how to test a building for airtightness. We discuss this more in the Section below on Intended Ventilation.

- **Mould and condensation appear**

Bathrooms need ventilation to be managed or humidity will become far too high causing condensation and subsequent mould. Extractor fans are normally used, with newer types recovering heat via a heat exchanger. In kitchens we should

Carbon Monoxide (CO) poisoning risk

Carbon monoxide is a colourless odourless gas so you cannot see or smell it (CO as distinct from CO_2). In a room with a combustion device it is essential to have enough fresh air to ensure proper, safe combustion. Otherwise there is a serious risk of carbon monoxide poisoning.

Combustion devices include an open fire, fuel-effect fire, closed wood or coal burning stove, gas or oil cooker, open flue boiler (typically floor-mounted as opposed to a new wall hung ‘balanced flue’ boiler, but some very old wall mounted instant water heaters are particularly risky).

This list is not exhaustive and there may be others. You are advised to have a carbon monoxide (CO) monitor/alarm in rooms where there is a combustion device. The requirement for this type of ventilation is covered by The Building Regulations Part J Combustion Devices and Fuel Storage Systems.

If you discover there is no or limited ventilation, you should stop using the combustion device immediately and have a qualified person check it and the room.

have extractor fans that vent to outside and somewhere for fresh air to come in. Often hob filters do not extract to the outside, but recirculate it in the kitchen, so the CO_2, steam etc. will remain inside. In kitchens and bathrooms a good extractor fan deals with the issue well. A little rotating plastic wheel, cut into a window is completely inadequate. Of course, when an extractor fan is blowing stale air out of the house, fresh air is coming into the house somewhere else to replace it, so extracting from a bathroom or kitchen will tend to help ventilate the whole house.

In other rooms, opening a trickle vent or window is likely to be the simplest solution if air quality gets poor.

In a bedroom overnight the typical indication of inadequate ventilation is a lot of condensation on windows and possibly external walls. Sleeping with the window open is a personal choice, but an expensive one in terms of heat loss and should only be done if air quality is an issue. Condensation is normal for a single-glazed window in very cold weather and frost may even appear on the inside of a window. If this dries out during the day there is probably enough ventilation. If condensation is found on good quality double glazing, say on a third of the pane, there is probably not enough ventilation especially if it does not dry out during the day and mould starts to grow.

In the worst cases, black mould may be found in the corners of rooms or behind static furniture where there is virtually permanent condensation. This is not uncommon in a Victorian house with a solid wall which has had double glazing fitted but without trickle vents, or with too few. The worst rooms are likely to be the bathroom or a small bedroom with two outside walls. However, it may be found in any room. Do also check for other sources of damp; an overflowing gutter or rising damp can cause the same effect.

Condensation examples

This cold corner of a room with a solid wall shows just a smattering of black mould; not a worry if it stays like this.

Here, in a window reveal, this is a worrying level of mould, and something needs to be done.

AIRTIGHTNESS TESTING

There are now tests which can be done to find out how airtight a building is. These can be useful to identify what is the priority order of work to get your house heat pump ready and what specific work needs to be done.

The level of draughtiness or airtightness in a house is dependent on its age and construction type. Old, single-glazed sash windows are very leaky and details such as the type of plaster used on the wall and the extent to which the pointing between the bricks has deteriorated are all important. It is also dependent on the improvements that have been made to the house since construction. These might include double glazing or draught proofing or the replacement of a suspended floor with a solid concrete one.

Our first guide, **Housewarming Guide H1: Taking Stock**, suggested using thermal imaging to give an indication of where your home is most leaky. You could also compare the amount of energy you use to heat your home depending on the internal and external temperature over time which can help identify where heat is being lost. You could ask someone to perform an airtightness test which might cost up to £500 but it includes help in finding leaks so you can seal them up.

Defining Airtightness

Any house can have its airtightness measured using ‘blower door’ or pulse testing. For both tests the house needs to be made ready. This includes ensuring all windows are closed and installing the testing equipment. The weather must be calm. The house is then tested in around an hour and a result obtained. A pulse test may be less useful, as it cannot be used to find leaks, simply to determine how leaky a building is.

During the blower door test it is possible to find where the bigger leaks are coming from. This can be done by using a thermal imager, by looking for swirls of dust or by using a smoke test. Once found, any leaks may, if required, be sealed up and the building re-tested.

The blower door test result is given in units of m^3/m^2hr at 50 Pa (or Pascal, a unit of pressure). The pulse test uses similar units but at 4Pa. This measures the air volume in cubic metres (m^3) that leaves a house per average square metre (m^2) of surface/ floor area every hour (hr) when the pressure applied between inside and out is 50 Pa (4Pa for the pulse test). Normal atmospheric pressure is about 100,000 Pa. The 50 Pa (4Pa for the pulse test) is the differential pressure created above the prevailing atmospheric pressure. The result allows a comparison between buildings and ‘norms’ required for good ventilation and/or energy efficiency. The number on its own is not easily convertible to ventilation rate.

The table below illustrates the typical recorded range of airtightness test results in UK homes. It shows the technical measure of airtightness now used in the UK in tests of new buildings, m^3/m^2 hr at 50 Pa.

Building	**Airtightness test result (m^3/m^2 hr at 50 Pa)**	**Comment**
Victorian building, old, single-glazed sash windows, open fireplaces, suspended wooden floor.	**~25 to 50**	Highly ventilated building, good air quality, the wind whistles through gaps, rattles the worn windows and creates uncomfortable draughts. Almost certainly need to close gaps to save energy as air quality will remain good.
1960s house with solid plaster walls, double glazing, one open fireplace, solid floor.	**~10 to 15**	Draughts noticeable only in gales, well ventilated but probably not excessive. Would benefit from some reduction in gaps e.g. chimney balloon, and then perhaps some controllable ventilation, e.g. trickle vents.
1990s house with dry-lining on lightweight blocks, open cavity, lack of attention to airtightness in build, wooden double-glazed windows in need of maintenance.	**~15 to 20**	Dry-lining internal walls with plasterboard became popular in the 1990s for its speed and low build cost. However, it became apparent that this leaves houses very air leaky. Having the cavity wall insulated would improve this; alternatively, work on finding and sealing gaps.
Conventional new build house. Many older properties achieve this with double glazing installed.	**~7**	Specifically designed and built to have the 'right' amount of ventilation so no need to improve. New houses are tested, measured, and allocated an airtightness number that must be below $8m^3/m^2/hr$ at 50Pa to meet building regulations. If the house is often full you may need to open trickle vents and/or windows to maintain good air quality. Extractor fans could be replaced with heat recovery units (see Section below).
Airtight new build house or retrofit with energy in mind. Occasionally find well-built older buildings this airtight.	**3**	Attention to detail in airtightness during build, excellent draught proofing on windows and doors, no chimneys, solid floor. At this level of airtightness Mechanical Ventilation with Heat Recovery is highly recommended. Ventilation needs to be actively managed to ensure good air quality.
Passivhaus	**(Different measure – 0.6 air changes per hour at 50 Pa) Mechanical Ventilation with Heat Recovery is essential.**	

These tests will help you, or the professionals you are working with, to prioritise and specify any work you need to stop heat loss through unwanted draughts. A very leaky house will benefit enormously from draught proofing and a ventilation strategy whereas an airtight house is likely to need little done in that regard, however wall insulation and/or improved glazing is likely to give a big improvement.

We suggest that you aim to make the fabric as airtight as you reasonably can and then make sure you have appropriate and sufficient means of allowing ventilation when you need it, e.g. trickle vents and/or MVHR units (see Section below).

Realistically, it will be a struggle to get most houses better than 7 m^3/m^2 hr at 50 Pa but with a concerted effort the best level could be achieved with the right remedial work to seal the leaks.

Some smaller flats in purpose-built blocks may already be very airtight as a by-product of noise- and fireproofing between flats. They would benefit from more controllable ventilation.

Blower door test equipment ready for testing.

TYPES OF INTENDED VENTILATION

In the ideal low-energy house, the fabric would be very airtight and there would be mechanical or passive devices to manage the ventilation to maintain air quality but not waste energy by allowing in cold air.

In this section we introduce some old and new ways of getting some ventilation.

PASSIVE AIRFLOW

- **Airbricks**

  There are three main locations for airbricks in a house.

- **Underfloor Ventilation**

These airbricks are visible below the damp proof course outside the house and should be kept clear.

In many modern homes (since about 2000) there has been a requirement to ensure that the space beneath a suspended floor is ventilated if there is a risk of ground gases collecting under the house. The main risks are radon, methane and landfill gases. Ventilation should not be blocked and has little effect on energy use.

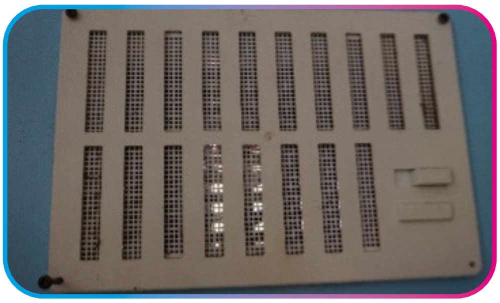
In older homes with suspended timber floors, airbricks were fitted to ensure that humidity levels did not promote rot and mould. The problem with this is that cold air comes in through the space under the floor (the underfloor void) and enters the house through gaps in and around the floor.

The floor will also be cold below and unless insulated will lose heat downwards. These do affect energy use but need to remain in place to keep the floor from rotting but can be insulated See **Housewarming Guide H2: Insulation**.

- **Cavity Ventilation**

These airbricks are also visible below the damp proof course but if you don't have a suspended timber floor, they must ventilate the cavity. If you live in an area with frequent, heavy, driving rain these need to be kept clear. In other areas they can be closed, but if the cavity is filled with insulation this will already have happened: the insulation will block them, which is not a problem.

- **Room Ventilation**



Airbricks are installed to provide ventilation to rooms. In many circumstances these can be closed, usually from inside. You should check overall ventilation and perhaps use a CO_2 meter.

These must not be confused with an airbrick allowing air for a combustion device, which must meet regulations to be legal and safe. Refer to Part J of The Building Regulations.

Airbricks are required by The Building Regulations Part F in certain circumstances, and they are specified by the number of mm^2 of free area for ventilation. A typical single airbrick is around $2000mm^2$ (2cm x 10cm) to $6500mm^2$ (6.5cm x 10cm).

MANAGED AIRFLOW - PASSIVE

In most houses some useful ventilation is achieved accidentally through the leaky fabric, but it is better to have controllable vents to help maintain good indoor air quality.

- **Trickle vents**

Trickle vents are the small, slotted vents typically found at the top of double-glazed windows. They are usually switchable from open to closed. They have been fitted to most windows since about 1990 when it was realised that good draught-sealing of new windows sometimes meant there was not enough ventilation.

In summer, it makes sense for these

Gases from underground

There are some locations in the UK where toxic or flammable gases are continuously seeping up from underground. The main risks are radon, methane and landfill gases. Radon is radioactive and is often found where granite is part of the local geology.

Methane is flammable and can be found near old mine workings or from seepages from natural reservoirs deep underground. Landfill gases are a mix of flammable and toxic gases and vapours and occur near to older landfill sites.

In all cases it is vital to ventilate away any that come up under the house and especially into the house. Where new houses are built in risk areas special construction techniques are used to prevent the risk becoming a problem.

Speak to your local authority to find out if you are in a risk area, or look online:

www.ukradon.org/information/

www.dbsenvironmental.co.uk/services/ground-gas-risk-assessment/

www.claire.co.uk/useful-government-legislation-and-guidance-by-country/77-risk-assessment-info-ra to always remain open as there is no heat to waste. In spring and autumn judgement is needed about how often they should be opened. It may be that in winter they should be shut, at least when you are not in the house. If you have signs of poor air quality as described earlier, and/or are measuring high CO_2 levels, then opening them to bring in fresh air is a good idea. Conversely, in an unused bedroom it is probably better to leave them closed, subject to checking this is not causing a slow build-up of condensation.

Examples of trickle vents are shown in the pictures below.

Trickle vents are usually required by The Building Regulations Part F and the area specified is related to the size of the room. A typical trickle vent is around 2000mm² to 5000mm² per window frame.

Two types of trickle vent from inside; top shows open, bottom shows closed.

- **Night Latch**

  Some windows also have a 'night-latch' setting where the window is locked just open to allow ventilation. This is especially found in top-hung windows, but this side-hung window has the same facility. The trickle vent is also visible at the top.

MANAGED AIRFLOW – MECHANICAL VENTILATION

Mechanical ventilation simply means that a fan is used to control the rate of air flow and hence the air quality or humidity levels in a room or home. This might be as small and common as extractor fans, or be a whole-house looped system with full heat recovery. We explore these overleaf.

- **Extractor fans**

  Older extractor fans can be noisy, feeble and a source of unwanted heat loss when off, because there is only a thin layer of plastic between the outside and inside. Even automatic ones seem to stay on too long. Newer ones are much quieter, better controlled and designed, and do an important job of keeping humidity down to acceptable levels.

Extractor fans have a rated air flow and often come with ‘background’ and ‘boost’ flow levels. The Building Regulations Part F requires a 6 litres per second flow rate in a small bathroom, whereas a utility room is required to have 30 litres per second if the fan is intermittent. There is now a whole house flow rate requirement based on the number of bedrooms, for example 25 litres per second for a 4 bedroom house.

These flow rates are proxies for air quality as they are regardless of size or how many people occupy the house, even though both these factors have a big effect on indoor air quality and the need for ventilation. They are, therefore, only guides.

In some cases of poor air quality in older buildings, perhaps with no damp-proof course and in a damp area, whole-house over-pressure ventilation is fitted. These units are very wasteful of energy but alleviate many of the problems of poor indoor air quality. They are typically just a large fan in the loft, blowing filtered fresh air into the house from the top floor.

MECHANICAL VENTILATION WITH HEAT RECOVERY (MVHR)

A mechanical ventilation and heat recovery unit recovers heat from stale air as it is pushed out of the building. The warm stale air passes through a heat exchanger and returns most of the heat to the incoming air. In this way fresh air coming in is pre-warmed. MVHR systems can recover up to 90% of the heat if well designed, installed and operated. They are designed to operate 24/7 at a background ventilation rate and boost when needed, such as after a shower.

These can be:

- **Individual room devices** which replace extractor fans or
- **Whole house (or whole storey) systems** which ventilate several rooms, extracting from ‘wet’ rooms and providing fresh air into others.

If it is clear a room or your whole house needs more ventilation, then replacing extractor fans with MVHR units will give good air quality with good energy efficiency too. If your house is already well ventilated (draughty) then there is no point having MVHR units as they will just increase the ventilation to an unnecessary high level.

As a rule of thumb, if your house has an airtightness test result of $5 m^3/m^2$ hr at 50 Pa, or better, they are worth fitting. At $3 m^3/m^2$ hr at 50 Pa they will be necessary to maintain good air quality and may need to be run continuously. If damp is a problem in a bathroom, then fitting a single room unit should help whilst not wasting energy.

The size/efficiency levels you need are determined by The Building Regulations.

SINGLE ROOM MVHR

The market for individual room devices is dominated by Vent-Axia's Lo-Carbon Tempra unit which has an efficiency of up to 80%.

Example single room MVHR Units:

Vent-Axia's Lo-Carbon Tempra
Direct replacement for an extractor fan.

The first two examples below can be installed as a simple replacement

Vent-Axia Low Carbon Tempra.

Kair Heat Recovery Unit: 86% heat recovery.

Vent-Axia HR200WK Heat.

for a through-wall 100mm diameter extractor fan. Vent-Axia manufacture their HR200WK Heat Recovery Unit specifically for kitchens and utility rooms.

If you are considering single room MVHR as part of a whole house energy retrofit, then it is vital to consider how the devices will fit when any wall insulation is installed. You must make allowance for the new wall thickness when choosing the lengths of ducts that go through the wall.

RETROFITTING WHOLE HOUSE MECHANICAL VENTILATION WITH HEAT RECOVERY (MVHR)

Whole house MVHR systems are very high performance but come at a cost; they are more complex, and they only make sense if the house is already very airtight. In a 'leaky' house they add to air changes rather than managing the right amount, and so waste more energy. MVHR may be difficult to retrofit unless work is being done in parallel, such as a major refurbishment or extension. They cost between £3,000 and £30,000 fully fitted depending on the complexity, efficiency and brand.

The resulting bill for all airtightness, insulation and MVHR installation work may be around £100,000, though the result should be an energy-efficient house with good air quality.

Ducting is usually hidden in the loft or between floor and ceiling but in some houses may have to visible.

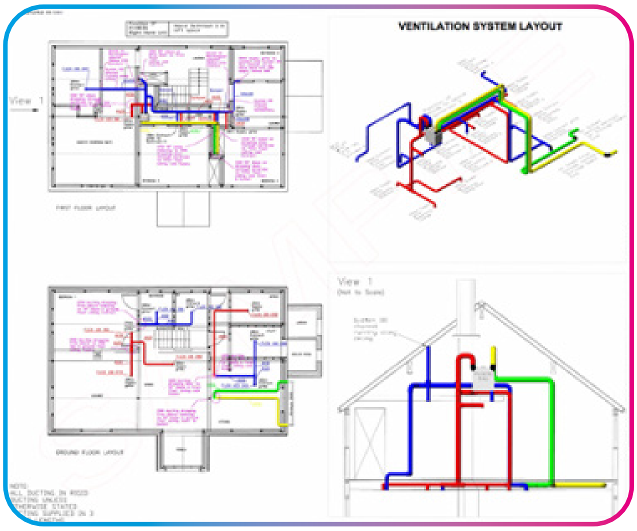
We recommend you employ an experienced specialist (architect or project manager) to assist you in choosing and designing such as system. There are many interactions to consider

Whole house MVHR fan and Heat Exchanger Unit

in the design which will only be apparent with experience. For example small ducts may be cheap but they can cause noise and increase the electricity consumption of the fans.

MVHR systems have a central fan and heat exchanger unit, usually in the loft area, and ducts which run around the house to individual rooms. One set are the extract ducts and the other are the fresh air intake ducts. Retrofitting the required ducts involves the removal of ceilings and/or floors in every room unless they are hung off the ceiling or in boxes built out of the walls. There needs to be a space centrally for the main fan and heat exchanger unit which is about 800mm x 800mm x 400mm plus access for maintenance.

In the right circumstances they provide excellent ventilation and air quality without losing heat. A well designed and installed system will use a little electricity, but this is far outweighed by the heat saved.



Example layout sketch of ducts for whole-house MVHR.

There are many manufacturers of MVHR systems from the top-end Passivhaus super-efficient unit to more standard devices for new build houses; example companies are Vent-Axia, Nuaire, Renovent, Airflow, Heatrae Sadia, Paul, Zehnder and others.

One website to browse if you want to learn more and which has a very large range of MVHR equipment is:

www.i-sells.co.uk/ventilation-heat-recovery

SENSORS AND CONTROLS

As for any heating system, extractor fans and MVHR should be controlled properly to work best. Even the most efficient MVHR unit will waste energy if set to run 24/7 at boost output. Whole house MVHR units should be supplied with a control system and manual. The basic control will typically allow a choice of airflow from low to boost by time of day. Most have a night time low setting to make them inaudible.

A more comprehensive control system will have input from sensors for CO and humidity. These will allow the MVHR to respond to varying levels of CO and humidity and provide the correct amount of ventilation to suit.

At the upper price end, you should get pollen filters, active automatic controls and possibly inbuilt heating and 'comfort-cooling'. The simplest may be a humidity sensor in a bathroom which therefore increases ventilation rates after a shower. Typically, a background low level of air is constantly flowing.

This example shows a comprehensive air control monitor.

COMMON SOURCES OF UNWANTED VENTILATION OR DRAUGHTS

In order to best balance energy efficiency with air quality, we need to be able to choose when to ventilate and how much. That means we need to know where the unwanted ventilation is and block it up, leaving the controlled sources of fresh air.

HOLES!

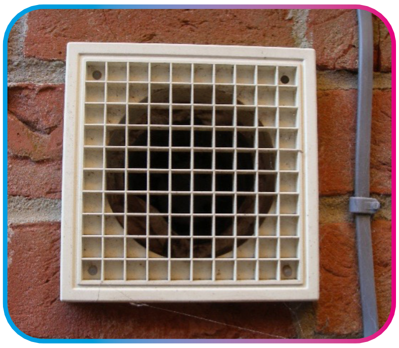
Houses are generally full of holes even though we may believe they are sealed! Below are some photos of holes that need not be there. Many can easily be fixed.

You should also consider cat flaps, letter boxes and key holes as these can all be sources of small draughts.

Holes can either let cold air in or warm air out depending on where the hole is and the weather conditions. This means a hole in a room upstairs may not be obvious – no cold draught – but it is letting warm air out. When warm air leaves, cold air must come in somewhere else to replace it. This will need heating and so add to your heating bill.

Sink waste pipe with large hole in wall not filled.

Daylight between door and frame – draughts!



Extract fan with no louvres to prevent wind blowing back in.

Old hole not filled.

Broken bricks reveal cavity behind.

Boiler flue hole not sealed around after installation.

WINDOWS AND DOORS

Draught-proofing of doors and windows has improved considerably over the past 20 years. We mentioned in the guide on windows and doors, that older doors and windows, even if they have double glazing, do not have such good draught strips as newer ones. In the oldest single glazing there may be none at all. This will be a big source of cold draughts in windy wintry weather.
The opening windows of new double glazing have two sets of draught strips and many are pressure tested to ensure they do not fail in windy conditions. Triple glazing systems may have three sets.

Windows and doors also wear or distort with age. The wood is worn down on the threshold or in the sashes; a worn or bent hinge will mean the window or door does not properly shut; and a gap appears between frame parts, letting the wind through. External doors, normally being on the ground floor, are associated with cold draughts.

LOFTS

Hatches or doors from a room into the loft are often not well draught proofed. However, they can be a big source of air leaks. Because they are at the top of the house, the leak will normally be of warm air leaving and so this is not often noticed.

On the top floor, badly fitted ceiling light fittings and gaps around pipes leading into the loft are also sources of unwanted ventilation. These should be sealed.

In a loft conversion, the wind often gets under the loft floor at the edges of the room. Most loft conversions do not seal the edge of the loft floor so this means cold air gets between the ceiling of the floor below and under the floor of the loft room – double the disadvantage. It is an awkward job to seal, working all the way around the edge of an existing loft conversion, but the benefits can be large and so this is usually worth doing.

CHIMNEYS

Open chimneys are a big source of air leakage in a room. There are several products which allow you to block the chimney temporarily if you use the fire infrequently or it is not used. Chimney balloons are a good option, but NOT a chimney damper as they will melt and collapse if you accidentally use the fire before you take them out. You should NOT have a chimney damper as these risk Carbon Monoxide poisoning and are not permitted when a gas fire is fitted in the fireplace.

https://www.legislation.gov.uk/uksi/1998/2451/contents/made

A modern chimney may have airflow control

The Energy Saving Trust has some advice on this:

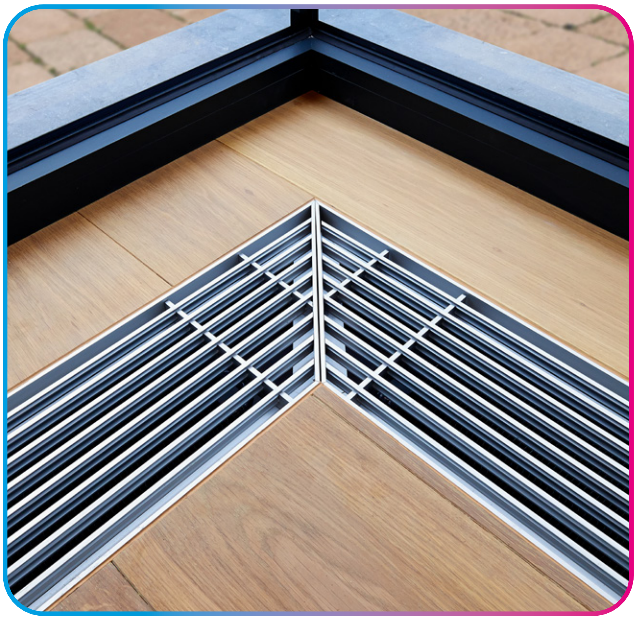
www.energysavingtrust.org.uk/how-draught-proof-your-chimney/.
If you have a closed stove this is better than an open fireplace especially when not in use. It will still draw fresh combustion air from the room when in operation and so cold air must enter the room but there is much less than for an open fire. The best stoves available now are room-sealed stoves which have a dedicated air intake to the stove from outside avoiding cold air coming through the room.

TOP TIP: **Remember, it is vital to have sufficient ventilation for an open fire or there is a safety risk with carbon monoxide poisoning. If you are draught proofing a room with a combustion device, please seek appropriate advice and conform to The Building Regulations Part J Combustion Devices and Fuel Storage Systems.**

If you have a closed stove fitted then you should have a 'register plate' at the bottom of the chimney to support the flue and close off the chimney. This might not be sealed properly and so you could still be losing warm air through the chimney.

AIRBRICKS AND SUSPENDED TIMBER FLOORS

Airbricks can either let cold air in or warm air out depending on where the hole is and the weather conditions. They probably need to be there to ensure good air quality and so, unless you have an air test and MVHR, then leave them. You could check air quality, for example by using a CO_2 meter, before blocking them.



Suspended timber floors can be ventilated

DRAUGHT PROOFING

SIMPLE DRAUGHT PROOFING

Simply applying draught proofing can make a huge difference to your energy bill. Small holes around pipes or where a pipe once went can be filled permanently with mortar, a mastic or some other filler. Draught proofing around doors and windows is the number one task, but also consider cat/dog flaps (some especially draught proofed designs are available), keyholes (with keyhole covers or escutcheons) and letter boxes.

Fitting draught excluder strips can be a DIY task, but this has to be done carefully to be really effective. Treat it as a skilled job! There are many types on the market, but only the metal ones are really durable.

Stormguard is a good example manufacturer and has a comprehensive set of products in this category with superb illustrations of how they work on their web site:

https://www.stormguard.co.uk/stormguard-products/

Some draught exclusion work may need some carpentry to first set the 'stops' of the door to make the gap smaller or more uniform in width.

SUSPENDED TIMBER FLOORS

Some ventilation is important under a timber floor to prevent rot and mould but it needs to be right or it just adds to your energy bill

DRAFT PROOFING OPTIONS

Foam	Squashy foam strips that you stick to one side of a window or door frame. These squash and fill the gap when closed. They may not last more than a couple of years and so need regular replacement but are great for stopping a draught from a window that is rarely opened.
'P-section' Rubber	Similar to above, but for slightly larger gaps and often an original fitting in a window or door frame. Can be tricky to retrofit.
Flat Strips	In metal or plastic, the metal type has been used for decades around door frames. They spring back to stop the gap around the door frame. Plastic ones are typically self-adhesive. The metal ones are more easily adjusted and can be bent back into place of they get damaged.
Brush Strips	For the biggest gaps, especially a letter flap, under a garage door or edge of a cat-flap.

as cold air comes up into the house.
To prevent this, ideally lift boards and add an air sealed but breathable membrane when installing insulation (according to manufacturers' instruction and any certification). This stops air flow from below into the house and insulates the floor surface from the cold air. The membrane needs to be fitted tightly right up to the edges of the room or air will escape past it and under the skirting boards into the room.

A partial solution is to fill all gaps between floorboards with a mastic of flexible filler so air cannot get past.
A good bead of mastic to seal under the skirting board will also help. The disadvantage with this approach is that as the floor flexes the sealant can crack away from the floor and reveal the gaps again, and it may dry out in a few years.

See our **Housewarming Guide H2: Insulation** for more information on solutions including intelligent airbricks.

Carpets are of limited value alone. A really thick underlay will help a little but if you are having new carpets fitted this is the time to seal the floor, seal the gaps, seal around the edges, and consider putting an airtight layer on the floor before the underlay that goes up under the skirting boards and is secured by them. However, be aware of the risk of condensation appearing beneath the floorboards if the underfloor void is not adequately ventilated.

IMPORTANCE OF MAINTENANCE

Draught proofing needs regular maintenance and eventually replacement as it wears out. Some parts of doors and windows should also have regular maintenance to prevent damage which in turn results in draughts.
Windows and doors, especially patio doors, need to be maintained according to manufacturer's and installer's instructions. This is likely to include annual lubrication and cleaning. If hinges are not lubricated the stiffness that results can mean the frame distorts when it is opened or closed so it does not shut properly. This can even be a long-term cause of 'blown' double glazing.
Dirt like grit and pine needles can stick in the frame damaging the draught seals so they do not work anymore.

Door seals especially are at risk of damage as people with shopping, parcels or bikes bump into the seals. These should be checked from time to time.

Cracks in plaster which have been filled can open up again over time. The repeated cycle of absorbing moisture and drying out again inevitably allows cracks to reappear. This is most likely where the wall meets a wooden frame or the ceiling.

When any other maintenance or replacement work has been carried out on pipes, for example unblocking a drain, it is important to check that gaps around them where they go through a wall have been filled once work is complete.

Extractor fans and MVHR units and trickle vents should be checked annually to ensure that they are not blocked by dust, cobwebs or even insects or wasp nests. Some have filters which need regular replacement; this includes cooker hoods.

SUMMARY

Air movement in the home is intangible and both a benefit in terms of fresh air and a potential cause of high energy bills.

You can feel cold draughts or smell the resultant mould if the rate of ventilation needs addressing, but you may not relate this to the need for less or more air flow. The difficulty is in assessing the right amount of air movement and how to achieve this. This is the least defined of the tasks involved in improving your home but it has to be tackled as it can result in half the heat loss.

Partly because it is so important and partly because the solutions are not well defined, there are opportunities for DIY and piecemeal interventions. Trying different types of draught proofing, installing a better extractor fan, painting up the gaps in windows – they don't all need to open – are all small changes it is easy to make quickly.

At the other end of the scale, having a fully functioning mechanical ventilation system with heat recovery installed could be the pinnacle of your energy efficiency improvements after all the other upgrades have been completed, especially airtightness, which needs to be very good for MVHR to be worthwhile.

Similarly, the biggest reductions in air flow may come from these other improvements: from replacing old windows, sealing the floor, insulating the external walls. These interactions demonstrate why we are stressing the whole house approach and the need to think about your home as an entity. We have one more detailed guide to consider and then will bring all the aspects together in **Housewarming Guide H6: Whole House Plan**.

Carbon Monoxide (CO) and Carbon Dioxide (CO_2) poisoning

In a room with a combustion device, it is essential to have enough fresh air to ensure proper, safe combustion, otherwise there is a serious risk of carbon monoxide poisoning (CO as distinct from CO_2).

Combustion devices include fireplaces, closed wood or coal burning stoves, gas or oil cookers and open flue boilers. Flue boilers are typically floor-mounted as opposed to a new wall hung 'balanced flue' boilers, but some very old wall-mounted instant water heaters are particularly risky.

This list is not exhaustive and there may be others. You are also advised to have a carbon monoxide (CO) monitor/alarm in rooms where there is a combustion device. The requirement for this type of ventilation is covered by The Building Regulations Part J Combustion Devices and Fuel Storage Systems. If you discover there is no such ventilation or suspect it is inadequate, you should stop using the combustion device immediately and ask a qualified person to check the device and the room. You can monitor your air quality with a carbon dioxide (CO_2) meter.

DISCLAIMER

This guidance document is written with the intention of providing a better basis for home owners to decide how to reduce the energy consumption and carbon emissions of their homes.

We have not surveyed your home and so the suggestions and discussions in this document can only be a general guide and LCON and its consultants cannot be held responsible for or accept any liability for damage, failures or disputes which result from the use of this document.

We recommend that specific decisions are made only after a suitable survey by an appropriately qualified specialist.

We recommend gaining several quotes for work from a number of suppliers and suitably qualified and experienced companies with appropriate insurance.

It is essential to follow material manufacturer's instructions and specification sheets to avoid risks of damage to structure and property and to ensure the intended performance is achieved. We recommend the use of only those products with appropriate independent certification for the intended use e.g a BBA (British Board of Agreement) certificate.

We recommend appropriate contracts are used and signed by all parties before work is undertaken and suitable legal advice should be sought.

CREDITS

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