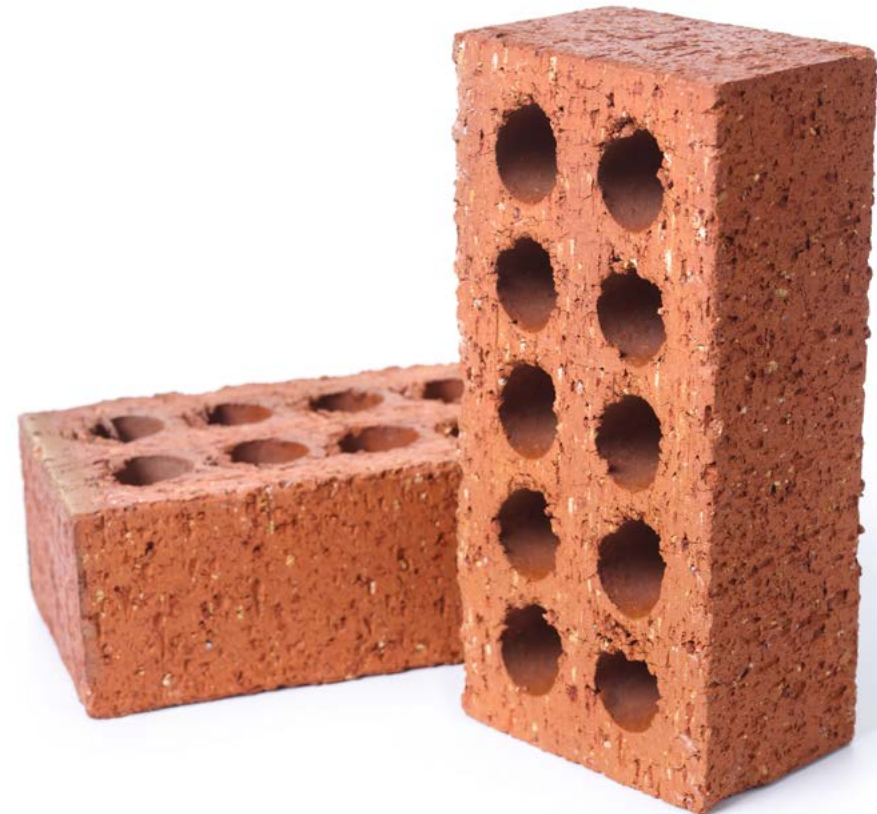




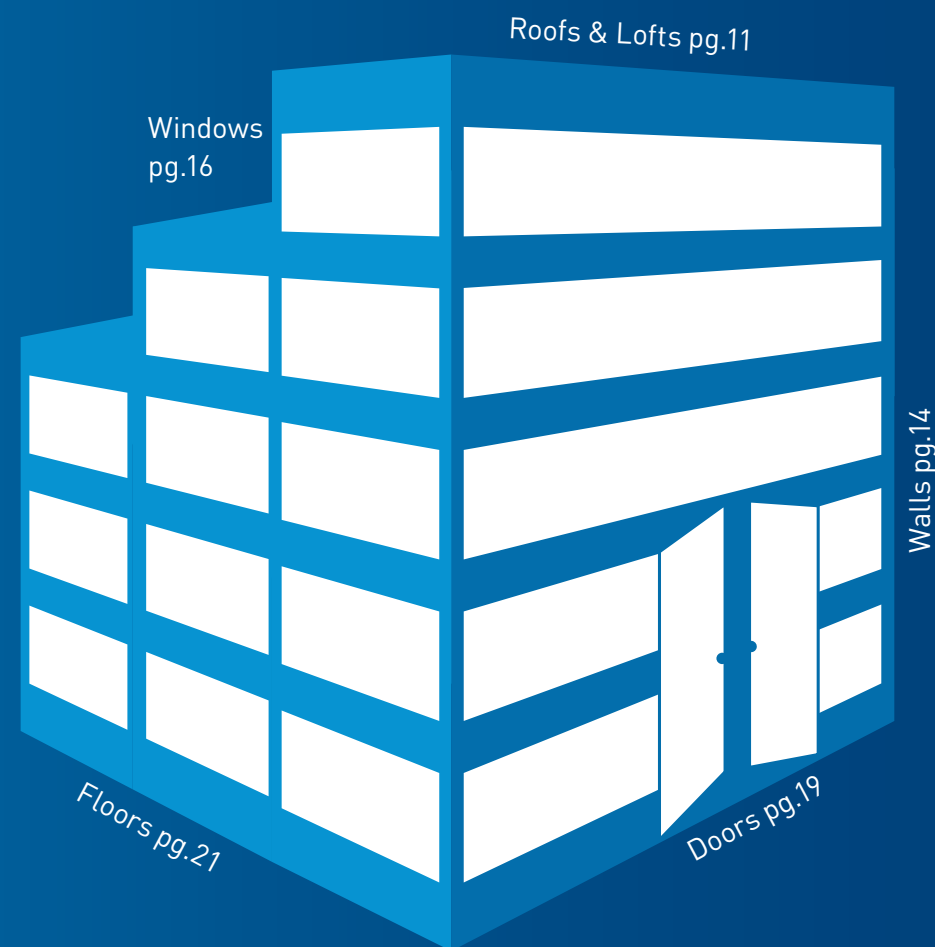
Building fabric

Energy saving techniques to improve the energy performance of buildings



Contents

Preface	3
Introduction	4
Building fabric and energy consumption	5
Importance of external factors	7
Opportunities for energy saving	9
Next steps	22
Go online for more information	23



Preface

Reducing energy use makes perfect business sense; it saves money, enhances corporate reputation and helps everyone in the fight against climate change.

The Carbon Trust provides expert, effective advice to help organisations take action to reduce carbon emissions. **The simplest way to do this is to use energy more efficiently.**

This overview introduces the main energy saving opportunities that exist in building fabric, demonstrating how simple actions can save energy, cut costs, and increase staff wellbeing.

Introduction

Improving a building's fabric is a smart investment.

Taking a "fabric first" approach is fundamental to the energy performance of a building. The building fabric refers to the roof, walls, windows, floors and doors of a building.

Improving and maintaining the building fabric offers many advantages and opportunities:

- Reduced energy and maintenance costs
- Better temperature control and thermal comfort for occupants
- Improved productivity
 - Output and morale are enhanced through reducing draughts, solar glare, overheating, colder areas, as well as noise.
- Lower capital expenditure
 - A more efficient, well-insulated building requires smaller heating and cooling systems, or even none at all.
- Good investment
 - Better insulation or well-maintained/modified building fabric can increase a building's value and aesthetics.

- Compliance with regulation
 - The government stipulates a minimum efficiency requirement for both new build and existing buildings.

Typically, there are two approaches to improving the building fabric: whole-building refurbishment, or a single measure approach.

Whole-building refurbishment offers the opportunity to make significant energy savings and maximise the cost-effectiveness of upgrading the building fabric. For example, combining the installation of insulation with new windows will enable the design and deployment of an optimised low energy heating, ventilation and air conditioning (HVAC) solution.

Single measures are targeted, often opportunistic, interventions and therefore the most common type of building improvement project. These often consists of either roof insulation, wall insulation, new windows or draught-proofing. Whilst this approach can achieve improved energy performance and comfort, it is

important to consider how the improvement measure might impact on the function of the rest of the building. For example, adding insulation to a building should always be preceded by a review of ventilation provision to safeguard against surface or interstitial condensation occurring.

Who is this publication for?

Building owners and managers, energy managers, financial teams or anyone who wishes to improve internal comfort levels whilst reducing heating and cooling costs. In particular, this guide is useful to anyone who could benefit from the knowledge that building fabric should always be addressed first, so that HVAC systems can be optimised to operate at maximum efficiency, thereby minimising energy costs.

Building fabric and energy consumption

The design and specification of the building fabric is a major determining factor of energy use in any building. Efficient, smart design reduces consumption and costs, and offers occupants comfort and flexibility.

Both ventilation and air conditioning requirements are affected by building fabric, however heating usually has the largest overall energy cost implication and impact on thermal comfort.

Typically, two thirds of the heat generated in a building is lost through the building fabric. The remaining third is lost through deliberate ventilation and uncontrolled infiltration through vents and gaps in the fabric, allowing warm air to leave and cold air to enter. Reheating the space to balance this loss can be an expensive waste of energy.

Fact!

An industrial building could be losing 75% of its heat through the building fabric.

The rate of heat loss depends on:

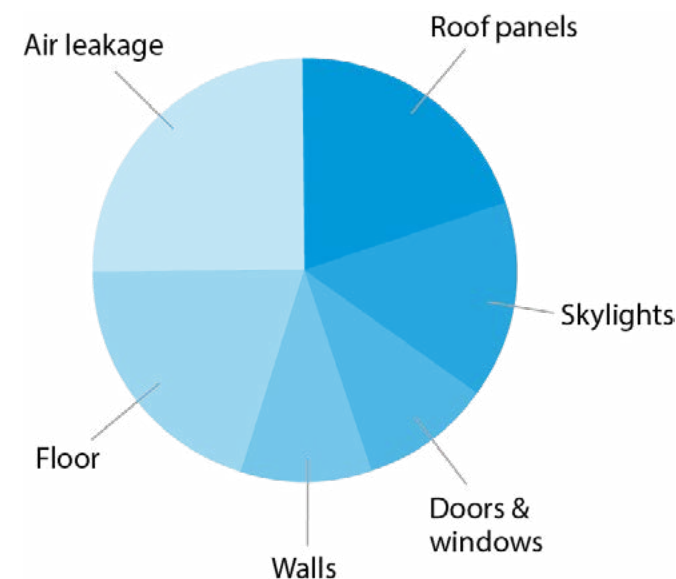
- Internal and external temperature difference.
- The rate at which the building fabric loses heat.
- The amount of fresh (outside) air entering the building either by controlled ventilation or uncontrolled infiltration.

- Fabric condition; a well maintained building loses much less heat, for example through being free from damp.

The ability of fabric to transfer heat is measured and expressed as a U-value. Different fabrics have different thermal (heat transfer) properties. For example, glazing is usually the part of the fabric least able to provide thermal resistance as it has the highest thermal conductivity.

The U-value of a building element (wall, window, roof, etc.) is an expression of the rate of energy flow (in Watts) for a given surface area (in m²) for a one degree temperature difference between one side of the element and the other (usually inside and outside). U-values are expressed on the Kelvin scale (K), but practically measured in degrees Celsius. The measurement for U-values is expressed as W/m²K. A lower U-value indicates better thermal insulating properties.

Figure 1 Breakdown of heat loss for a typical industrial building with a central valley gutter

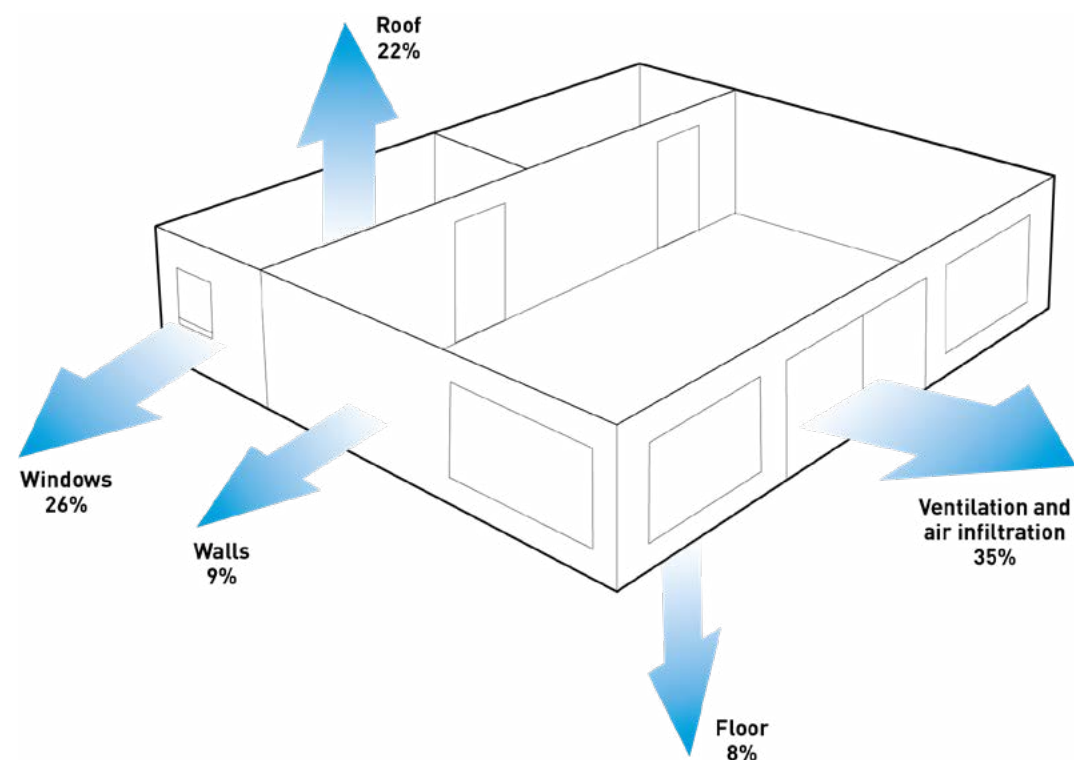


Thermal bridging

A thermal bridge is an area, either singular or recurring, in the building fabric that allows heat to be lost through passage from inside to outside; this is usually caused by missing insulation or a component that exists through the structure e.g. structural steelwork. Thermal bridging leads to cold spots on the internal surface of the building fabric, which in turn can lead to surface condensation, damp and mould.

Important: The impact of building fabric upgrades on HVAC requirements must be properly understood prior to implementation to ensure these systems can be simultaneously modified to respond to the reduced heat-losses or gains in the most efficient manner. Impact on ventilation requirements must also be considered and measures put in place to mitigate any resultant condensation risk.

Figure 2 This flow chart shows an approximate breakdown of heat loss.



Importance of external factors

The energy consumption of a building is affected by a variety of interrelated external environmental factors, which govern how a building responds to the environment around it.

Climate and weather:

Factor: Climate factors such as temperature, humidity, prevailing wind conditions, light, and solar gain greatly impact the energy use and energy efficiency of a building.

Potential: This presents opportunities to harness natural conditions to heat, cool and ventilate buildings.

Harness /mitigate: Smart design is key, however, there are also effective methods for harnessing the impact of climactic conditions on existing buildings. These methods can start with low-cost measures such as installing draught stripping, upgrading insulation or providing external shading. Increasingly, renewable energy technologies such as solar PV and solar thermal systems are being integrated into buildings to exploit beneficial external conditions. Their cost effectiveness is improved when they displace traditional building materials and should therefore be considered prior to roof and window replacement projects.

Orientation and layout:

Factor: The direction in which buildings face and the amount of shading from other buildings or plants has a direct effect on the amount of daylight and solar heat that enters the internal spaces.

Potential: There are clear opportunities to reduce light usage by maximising daylight, and reduce heating by maximising use of solar heat.

Harness /mitigate: Due to heated air rising, there is also potential to encourage effective natural ventilation through the “stack effect”. This uses pressure differences to **draw** air through a building. External shading, such as brise soleil, can be used to ensure solar gains don’t cause overheating, and to minimise glare.

Tip:

North facing rooms are often the coolest areas in a building, and so ideal for storing heat-emitting electrical equipment, such as servers, photocopier printers, etc.

This can reduce costs associated with cooling the equipment, and in fact provide space heating for the rest of the building.

Form:

Factor: A building's shape and proportion exposed to the environment will also affect internal temperatures and heat loss.

Potential: The smaller the external surface area of a building, the less opportunity there is for heat to escape, however this can also reduce natural lighting and ventilation.

Harness /mitigate: Getting this balance right is only really an option at the design stage, whether for a new building, new extension or significant alteration.

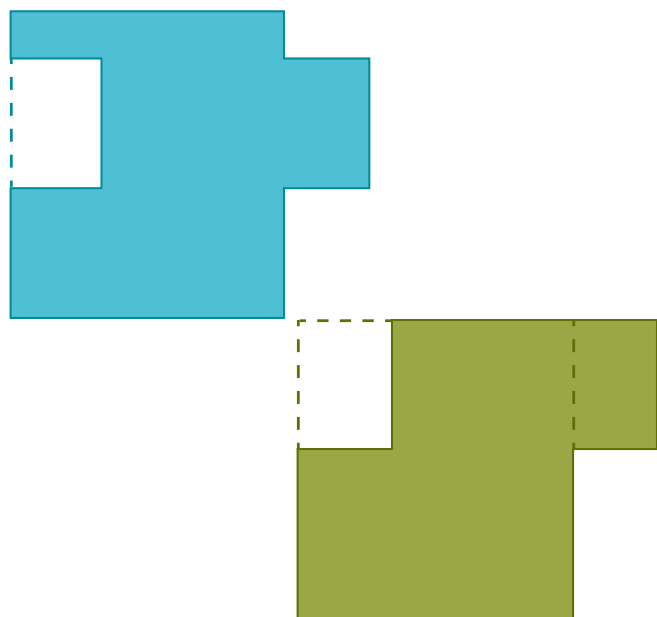


Figure 3 Variation in building forms showing differences in perimeter and wall area

Building airtightness:

Factor: Air enters and leaves a building both by controlled ventilation, such as windows and dedicated air vents, and through uncontrolled 'air infiltration', such as gaps and cracks in the walls and around window and door openings. Air infiltration does not ventilate a building in an energy efficient way. Buildings that leak air also leak money as additional energy is needed to heat or cool the outside air entering the building.

Potential: Improving airtightness enables more efficient ventilation, more effective temperature control, and reduces uncomfortable draughts.

Harness /mitigate: Increased airtightness and thermal insulation can sometimes result in newer buildings (particularly offices) overheating. This can be solved by using controlled ventilation (ideally with heat recovery) and responsive HVAC controls to optimise the level of heating, ensuring comfort and cost reductions.

Condensation:

Factor: Condensation can occur on the surface of, or within, the building fabric. **Surface** condensation occurs when warm moisture laden air makes contact with a cold surface that is below the dew-point of the air.

Interstitial condensation works on the same principles as surface condensation, except it occurs within the building fabric, usually on the cold side of any insulation. Thermal bridging is a common cause of interstitial condensation.

Potential: Surface condensation can be very detrimental to human health and comfort as it often leads to damp and mould growth. Interstitial condensation can be very detrimental to the building fabric as it can lead to decay and structural instability.

Harness As condensation occurs, the thermal conductivity of the building fabric increases, thus leading to more heat loss and energy consumption. Mitigation strategies include: ensuring upgraded insulation is continuous by minimising thermal bridging; applying a vapour barrier (to the warm side); and modifying the ventilation strategy.

Opportunities for energy saving

Insulation:

Insulation is among the most cost-effective and frequently employed methods for improving the energy efficiency of buildings. There are several types of insulation available for use within construction, some of which are available in a variety of forms (loose, semi-rigid and rigid). A brief outline is given below.

Natural and low embodied carbon insulation materials are always preferable. This is important as there is a risk that insulation with high embodied energy will not sufficiently reduce carbon emissions during its life expectancy to offset the emissions generated in their production, which can be extensive. In addition, natural materials are often vapour permeable and hygroscopic meaning they can assist with the movement of moisture, thus making them the preferred choice for traditionally constructed buildings.

Health and Safety

Prior to specifying, purchasing, handling or installing any insulation, its properties should be carefully reviewed to ensure that it is fit for purpose and this involves a review of the material safety data sheet. This will also inform the Personal Protective Equipment (PPE) required during installation.

Loose:

Mineral and glass wool: Mineral and glass wool come in blanket form or as loose 'chips' to be blown into place. They have good thermal performance and are vapour permeable, lightweight and non-combustible. Can be used in roofs at ceiling level, in internal partition walls and under suspended timber floors.

Installation difficulty: Moderate

Price: £

Embodied carbon: High

Sheep wool: Sheep wool insulation also comes in blanket and 'chip' forms. It is a natural alternative with similar thermal performance to mineral wool, is vapour permeable and hygroscopic, lightweight and is not flammable (it singes away from the heat and extinguishes itself). Can be used in roofs at ceiling level, in internal partition walls and under suspended timber floors.

Installation difficulty: Easy

Price: ££

Embodied carbon: Low

Cellulose: Produced from either natural plant fibres or more commonly recycled paper products. Generally blown into place, it provides good thermal

performance, is vapour permeable and hygroscopic, lightweight and has fire resistant performance (after being chemically treated). Can be used in roofs and walls.

Installation difficulty: Moderate

Price: £

Embodied carbon: Very Low

Hemp blanket: Produced from natural plant fibres and is renewable. Provides good thermal performance, is vapour permeable and hygroscopic. It can absorb about 20% of its weight in moisture without thermal deterioration, setting it apart from most man-made insulations. It is inert and therefore does not require any specialist PPE. Not naturally fire resistant. Can be used in roofs at ceiling level, in internal partition walls and under suspended timber floors.

Installation difficulty: Easy

Price: £££

Embodied carbon: Low

Semi-rigid:

High-density mineral wool slabs: this compacted mineral wool is less flexible, but also takes up less space in achieving lower U-values. As a result it is commonly used for walls. It has good thermal and fire performance and is vapour permeable. Can be used

under suspended timber floors, as well as in walls.

Installation difficulty: Moderate

Price: ££

Embodied carbon: Moderate

Hemp boards: This compacted hemp insulation is less flexible. It has good thermal performance, is vapour permeable and hygroscopic. Not naturally fire resistant. Can be used in walls and roofs at ceiling and rafter level. Can be used under suspended timber floors, as well as in walls.

Installation difficulty: Easy

Price: ££

Embodied carbon: Low

Rigid:

Expanded/Extruded polystyrene: Closed cell insulation boards derived from petrochemicals which provide good thermal performance, are lightweight and are impermeable to moisture. However, they are flammable. Requires toxic fire retardant to provide some fire resistance. Can be used in walls, floors and at rafter level in roofs.

Installation difficulty: Moderate

Price: £

Embodied carbon: High

Polyisocyanurate: Closed cell plastic insulation boards which are lightweight, have good thermal performance, are impermeable to moisture and often come with an integrated foil vapour control layer. However, they are flammable. Can also be sprayed on. Can be used in floors, walls and roofs at rafter level.

Installation difficulty: Moderate

Price: £££

Embodied carbon: High

Polyurethane: A spray on closed cell plastic insulation that reacts with the air to create an insulating, air sealed, moisture barrier. Available as both closed cell and open cell. Installation requires specialist contractor and not naturally fire resistant. However, very difficult to remove so will affect ability to recycle other materials at the end of the buildings life. Can be used on floors, walls and roofs.

Installation difficulty: Difficult

Price: ££

Embodied carbon: Very High

Phenolic foam: Closed cell phenol-formaldehyde resin based insulation boards which are lightweight and have very good thermal performance from minimal thickness. Have some natural flame resistance and moisture resisting properties. Can be used in floors, walls and roofs.

Installation difficulty: Moderate

Price: £££

Embodied carbon: High

Wood wool/fibre: Produced from timber waste. Good thermal performance, vapour permeable, hygroscopic and highly versatile. Requires fire retardant. Currently has to be imported, adding to the embodied carbon. Can be used in floors, walls and roofs.

Installation difficulty: Moderate

Price: ££

Embodied carbon: Moderate

Aerogel: Produced from silica aerogel combined with fibres. Superior thermal performance from a lightweight and thin board. Good fire performance. Can be used on walls, floors and roofs.

Installation difficulty: Moderate

Price: £££

Embodied carbon: High

Cork: Produced from the bark of the cork tree. Completely renewable and inert. Excellent thermal performance, vapour permeable and hygroscopic, lightweight and naturally fire resistant. Can be used in floors, walls and roofs.

Installation difficulty: Easy

Price: £

Embodied carbon: Very Low

Important:

Regularly check building fabric for damp, particularly in the most risk-prone winter months, as it drastically reduces insulation properties and can cause significant damage.

Ventilation

Ventilation is important to all aspects of building fabric, and must always be taken into consideration during the planning and execution of any insulation work.

Maintenance opportunities:

Double and triple glazing

By replacing single-glazed and poor fitting windows with double and triple glazing, air infiltration can be prevented and draught-free ventilation provided for better control.

Sealing cracks and gaps

This reduces uncontrolled infiltration and air leakage, allowing for both maximum efficiency and control of the installed ventilation system.

Blocking the chimney

Particularly relevant to heritage buildings, old, unused, open chimneys can be blocked up during decorating or other maintenance activities. This reduces uncontrolled ventilation losses and draughts. Ensure that sufficient controllable ventilation will be provided before blocking the chimney and that some residual ventilation is provided through the chimney to keep it dry.

There is a risk otherwise of dampness mobilising old combustion products, which then leach through the construction and cause staining of internal finishes and mould growth; these can in turn lead to serious health risks.

Refurbishment opportunities:

Utilising the stack effect

If addressed at the design stage of both new build and refurbishment projects, this can be maximised to provide natural ventilation throughout a building. The stack effect takes advantage of natural differences in pressure, causing cooler fresh air to be 'sucked' in at the lower level and warmer stale air to be expelled at the higher level. Care must be taken to ensure that this approach does not cause excessive heat loss, for example through the use of baffles.

Trickle ventilator

Trickle ventilators can be installed to provide background ventilation and to encourage cross-ventilation where possible. Importantly, they are gentle, and thus do not interfere with thermal comfort during colder months when the heating is being used.

Eaves and suspended floor ventilation

It is crucially important that ventilation is installed or maintained when insulating a cold pitched roof or suspended timber floor. This ventilation prevents condensation forming, which could have ramifications for the health of occupants from damp and mould, and the structural stability of the building from rot.

Extract ventilation

This is the removal of air directly from a space to outside. Extract ventilation may be by natural means (e.g. stack ventilation) or by mechanical means (e.g. an extract fan).

Important:

Heating, cooling and ventilation are all part of the same equation and must be balanced.

Changes to heating and insulation must include consideration of how this will impact on ventilation. Likewise changes to ventilation must include planning how this can impact other factors, particularly the formation of condensation. Failure to consider these holistically risks creating more problems than are solved during improvements.

Positive input ventilation

This system draws fresh air from outside and pushes this inside the building. The pressure builds up inside and forces air out through gaps, for example trickle ventilators. The system is usually located on the roof or in the roof space and can draw the air directly from outside through ductwork or through the eaves ventilators, which creates air movement in this area and therefore reduces condensation risks here too. It can also incorporate a heating element and/or heat recovery to pre-heat the air before entering the occupied space. These systems are particularly effective at eradicating and then preventing condensation, damp and mould.

Even something as minor as inadvertently sealing cracks and gaps can affect ventilation to the point of triggering a requirement for additional ventilation.

Roofs and lofts

Typically, over 20% of heat in a building is lost through the roof.

Behaviour change opportunities:

Inspect

It is always important to ensure roofs are in good condition; however, this is particularly pertinent for flat roofs. Keep an eye out for signs of damp, puddles of water, and any indication that the roof is changing shape – any of these can let in water causing significant, expensive damage. Also check for damage by rodents, nesting birds and other animals.

Upon finding any faults, take action immediately; this will minimise costs and severity. During maintenance in a loft space, lay walking boards if insulation hides where joists lie, and after, remember to check insulation has been put back to provide a complete covering.

Tip:

Insulate all pipework and water storage tanks in the roof space to reduce the risk of freezing and improve comfort.

Refurbishment opportunities:

Insulate

Installing loft insulation in an uninsulated pitched roof is likely to be the single most cost-effective way to improve the efficiency of the building fabric and save money. Insulated loft spaces in a building can reduce heat loss through the roof by over 80%. Upgrading existing insulation can also offer significant results (providing it is in good condition and not damp). If there is less than 150mm (6 inches) of loose insulation, it is always worth adding more, aiming for at least 270mm.

Re-circulate

In high roofed buildings such as industrial sites, rising hot air can collect at the ceiling – sometimes up to 10°C warmer than at working level. This contributes to a higher rate of heat loss through the roof.

Consider installing ceiling circulation, ‘**destratification fans**’, so warm air can be redirected down to where it is needed. In most cases the value of heat savings far exceeds the cost of the electricity required to operate the fans.

Ceilings

In multi-storey buildings it is often beneficial to insulate between ceiling and floor spaces. This can ease the difficulty of heating lower floors, whilst reducing the problem of overheating on higher floors.

Retaining high ceilings can however serve an energy efficient use in the right situation. The extra volume above occupied areas allows heat stratification, which combined with the thermal mass of the building can reduce the cooling load and associated costs.

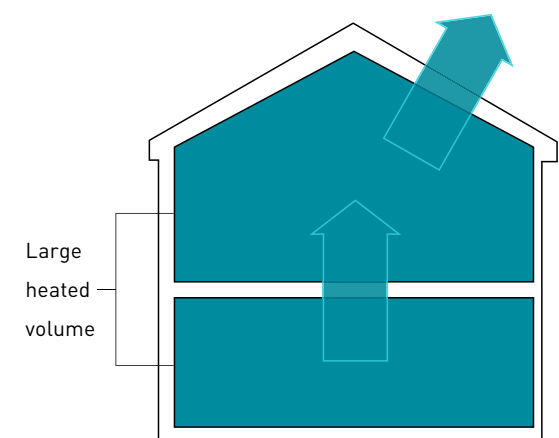
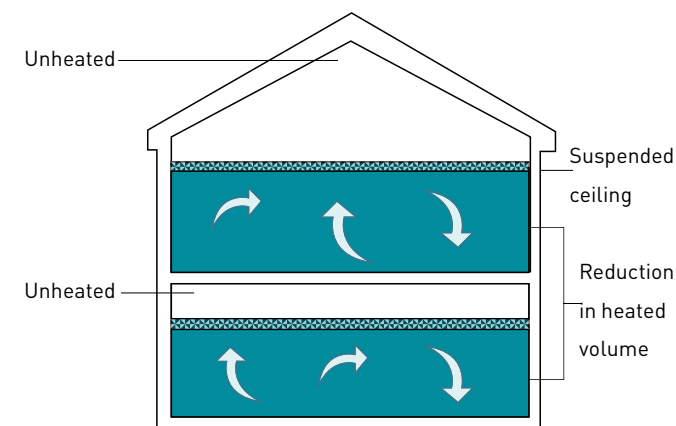


Figure 4 Heat loss through uninsulated stories

Figure 5 Improved heat retention due to inter-floor insulation

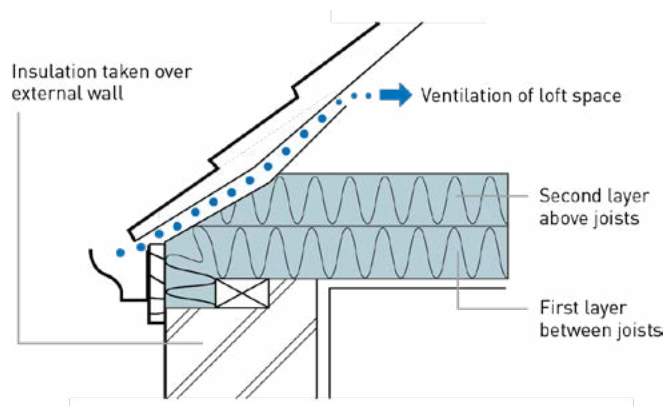


Designs:

Pitched roof

Insulating pitched roofs at ceiling level ('cold roof') offers relatively short paybacks and can be carried out at any time. Insulation must be installed carefully, making sure there are no gaps which can lead to thermal bridging, and the roof must be sufficiently ventilated to prevent condensation. A vapour control layer may also be necessary.

Figure 6 A cold pitched roof, with insulation at ceiling level

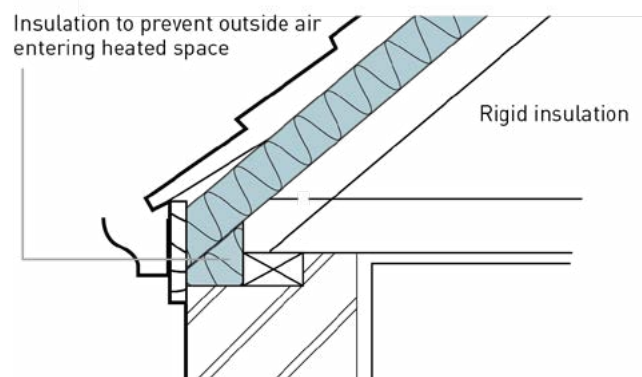


Alternatively, following a condensation risk assessment, a pitched roof can be insulated at rafter level – a 'warm roof'. This can be done using rigid insulation boards or semi-rigid insulation slabs, ensuring a 50mm gap between insulation and roofing felt / sarking.

Flat roof

Flat roofs can be more difficult and expensive to insulate than pitched roofs. It is not usually economical to add insulation unless carrying out repair or refurbishment work at the same time. As a result, installing insulation to make the flat roof a warm roof is most appropriate when the weatherproof covering has failed, or when the insulation needs upgrading. Adding insulation to the underside of the flat roof and thus creating a cold roof is not recommended due to the risks from interstitial condensation.

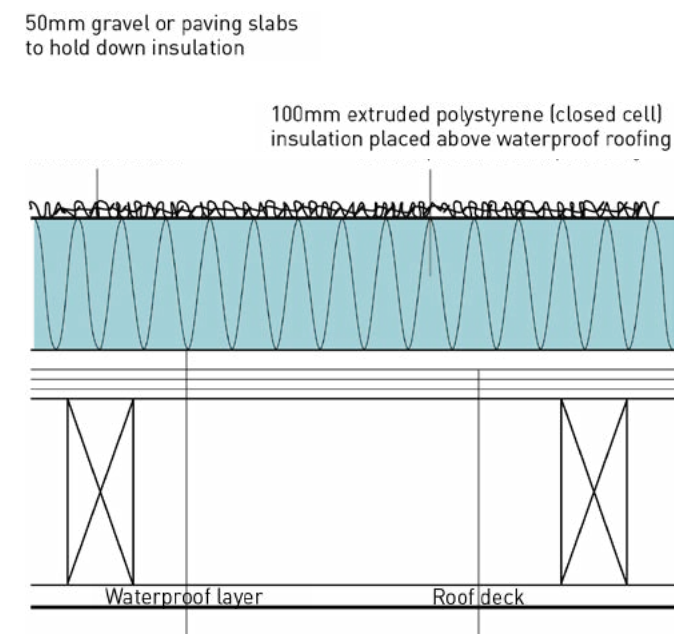
Figure 7 A warm pitched roof, with insulation at rafter level



When upgrading it is essential to check:

- The condition of the existing weatherproof covering.
- The thermal resistance of any insulation previously installed below the weatherproof covering.
- The ability of the roof to support the increased load.

Figure 8 An inverted warm flat roof



Walls

Around 9% of heat lost in a building is through the fabric of the walls.

Refurbishment opportunities:

Heat reflective foil

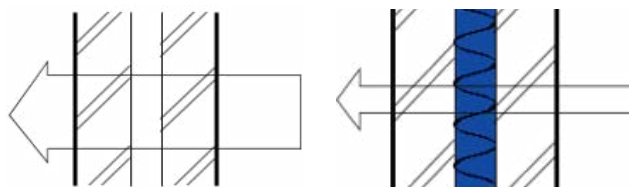
Heat reflective foil can be fitted behind radiators to reduce the amount of heat escaping. This is particularly recommended for radiators located on walls with an external aspect. Fit foil so that the shiny side faces the room.

Cavity wall insulation

Installing cavity wall insulation is relatively simple, preferably with expanded polystyrene beads. The procedure causes minimal disruption to building occupants, making it suitable to carry out at any time.

Buildings with hard to treat cavity walls and where they are exposed to wind driven rain and where cavities are not completely clear should avoid cavity wall insulation. There is a risk that moisture can be carried through the wall and appear on the internal surface. There is also the risk of gaps being left, leading to cold spots and thus causing condensation, damp and mould.

Figure 9 Cavity wall insulation

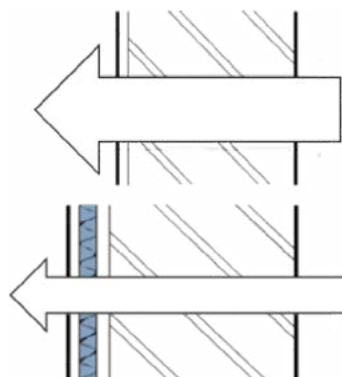


External wall insulation

One of the most common, and effective, methods of insulating solid and hard to treat cavity external walls is by applying insulation boards to the outer surface of the building and protecting it with a specialist render or cladding system. This process can be done in a new build construction as well as during the refurbishment of existing buildings. However, as with all fabric upgrades, it must only be applied to dry walls. It can often be mistakenly installed as a method of addressing damp, which just leads to the moisture being trapped and exacerbating the problem.

Insulated renders can also be used. A hemp lime render is an effective natural, low carbon option and can be applied to both the outside and inside of a building.

Figure 10 External wall insulation



This method brings several benefits:

- Reduced risk of interstitial condensation due to protection from extreme temperature fluctuations.
- Reduced opportunities for thermal bridging.
- Improved airtightness.
- Retention of thermal mass on the inside of the building.
- Can improve the aesthetic appearance of the building.

Internal wall insulation

External wall insulation is always preferable to internal, which, although an option, requires specialist advice to overcome potentially significant risks. Ultimately, it may simply create more problems than it solves.

One of the main problems is the introduction of unavoidable thermal bridging due to not being able to achieve a complete covering, primarily at internal wall, floor and ceiling junctions. Thermal bridging can have serious detrimental effects on both occupants and the structure.

Adding insulation to the internal face of solid external walls isolates internal heat from all the components embedded in the wall, as well as the wall itself, for example, floor joist ends, lintels over openings. This is particularly pertinent to older traditionally constructed buildings where these components are often made from timber.

Whilst internal wall insulation is a less expensive option, disruption to building occupants can restrict it to periods of refurbishment. When applying, consideration should be given to putting in amenities such as electric sockets and pipework; penetration of the insulation layer must be minimised in order to maintain the insulation's integrity.

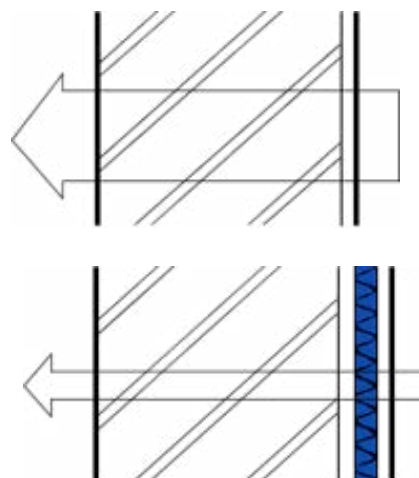
Exposing the fabric

Exposing the fabric to the air provides slower heating responses, and can therefore be incorporated into smart, efficiency-led design, reducing both heating and cooling demand.

Heavyweight building fabric like concrete and stone acts like a storage heater if exposed to the internal air temperature, as well as direct solar gain. Allowing heat to be absorbed by the building fabric in this way allows the building to heat up more slowly and to hold its temperature for longer.

This can be advantageous when the space is occupied for long periods, but where spaces are used infrequently, a fast heating response time is more desirable.

Figure 11 Internal wall insulation



Remember

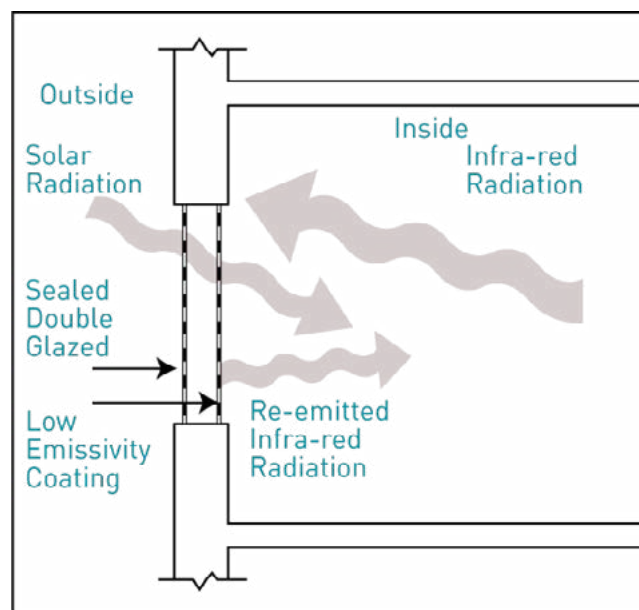
If a building is listed, such as a heritage site, the listing protects all services including boilers and pipework. It is therefore a criminal act to change anything without permission. If in doubt, seek professional advice.

Windows

Used effectively, windows can reduce requirements for lighting, heating and mechanical cooling. However, they can also account for over a quarter of a building's heat loss.

Glazing can let in solar heat, which can be beneficial in reducing heat requirements in colder weather. However, it can also make buildings uncomfortably warm in summertime or cold in wintertime for those next to the windows.

Figure 12 Solar gain and the role of glazing



Windows are made up of two components, the glazing and the frame. The main factors affecting a window's performance are:

- Number of panes of glass that make up a glazing unit (i.e. single, double or triple).
- Specification of the glass used.
- Type of gas used to fill the cavity between glass panes.
- Frame design (e.g. thermal break width).
- Glazing unit design (e.g. insulating spacers).

Behaviour change opportunities:

Keep windows closed

To reduce the loss of heated or cooled air, keep windows closed when heating or air-conditioning systems are in operation. Use the system controller(s) to achieve a comfortable temperature.

Make good use of natural daylight

Most people prefer to work in natural light. Occupants should therefore be encouraged to keep lights switched off when there is sufficient daylight; installing daylight sensors can help. Regularly cleaning windows and skylights also help to maximise daylight.

Redirect the sun

Direct sunlight coming into buildings through glazing can create glare problems. Often building occupants react to this by lowering blinds and switching on lights. Instead, users should be encouraged to angle blinds to reflect light onto the ceiling and into the workspace.

Draw curtains/blinds to improve comfort

Draw curtains and lower blinds at the end of each day to help keep warmth in during winter months. Equally, during summer, using curtains and blinds in rooms exposed to afternoon and evening sun helps lower temperatures.

Maintenance opportunities:

Regular checks

Regularly check windows and replace broken or cracked panes and frames. Fit draught stripping where appropriate and replace any sections showing wear or damage; this can be undertaken as an easy DIY measure.

Reduce draughts

Openable windows can be draught-stripped to reduce heat loss. Importantly, this needs to be balanced with a supply of background ventilation (e.g. trickle ventilators) to reduce condensation risk.

Top tip: 'the 1 pence test'

If a 1 pence coin can slide between a window and its frame, draught-proofing will be cost effective and improve comfort.

Refurbishment opportunities:

Improving glazing can be expensive and may only be cost-effective as part of a refurbishment project.

Double/triple glazing

Double glazing is now a minimum requirement when replacing windows (except where the listing or conservation area exempts the building), however installing triple glazing on north facing or exposed sides of a building can offer further comfort and savings.

High performance and low emissivity glass

High performance glass has a coating or a film applied to it to improve insulation properties. This redirects heat either back into the room or prevents it from entering the space from outside.

Coatings that allow daylight through but block or reduce heat can be particularly effective at reducing overheating from direct sunlight; thus lowering cooling requirements. However, this needs to be considered carefully if the heat from the sun is intended to be used to supplement (or even substitute) space heating.

An alternative short-term measure is to apply solar-control film to existing glazing. This may however impact daylight levels and alter the colour of the remaining light.

Replace glazing with insulation

In highly glazed spaces, a retrofit option is to replace some glazing with insulated blank panels. This provides better insulation at the cost of daylight, and also reduces heat and glare problems.

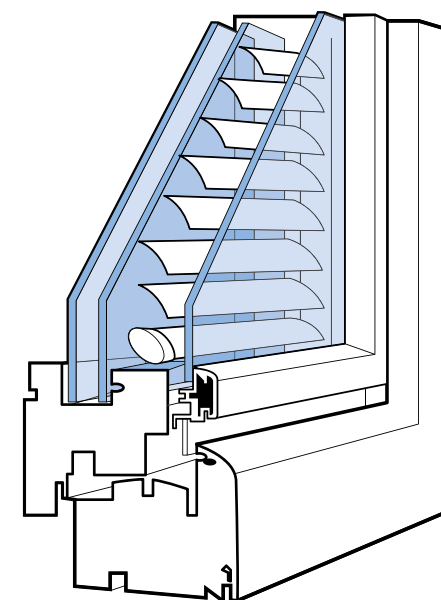
Provide external shading

Solar shading reduces unwanted heat and light from the sun during the summer, and can allow low-angled winter sun to provide some passive heating. It is most effective if combined with thermal mass, as well as measures to address overheating such as energy efficient lighting and appliances.

Although the heat from the sun is most intense on south facing facades, the sun's rays can be more problematic on the east or west facing facades, which are susceptible to overheating and glare when the sun is at a low angle.

Figure 13 Cross section of triple glazing with in-built louvres

Manufacturers have a wide range of products that may solve several problems at once. The glazing in this diagram will keep the heat in effectively, while the louvres could control glare and improve lighting conditions.

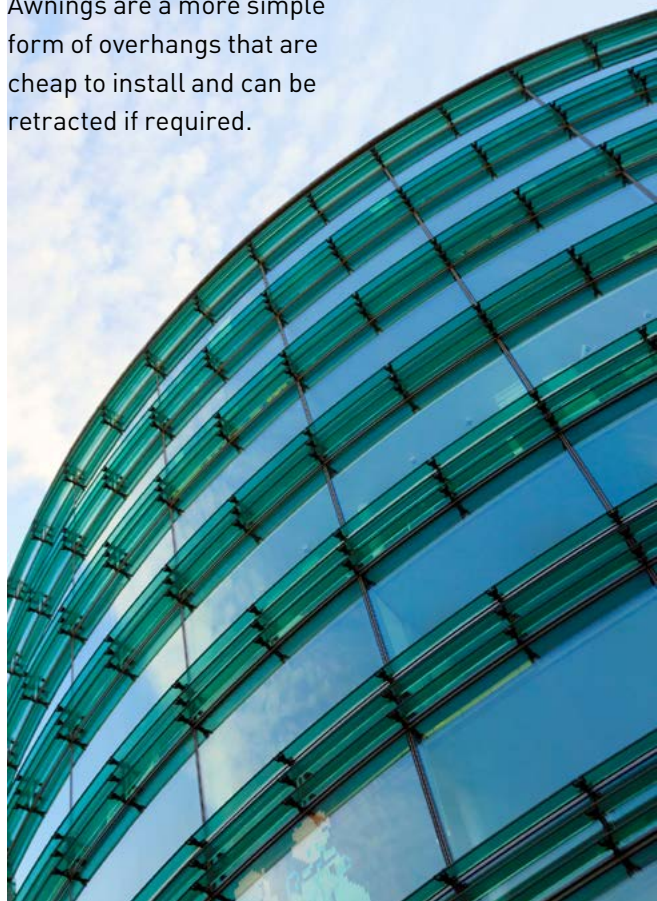


Types of external shading include:

Overhangs, awnings and light shelves

Overhangs, including 'brise soleil', are a simple, effective means of blocking out the high summer sun, without compromising low winter sun, and are usually installed on south facing facades. They can be integrated into both new-builds and existing buildings, and also provide protection for the external envelope.

Awnings are a more simple form of overhangs that are cheap to install and can be retracted if required.



Trees and vegetation

Planting trees and climbing vegetation can be used to provide shade and control of solar gain where space permits. Tall deciduous trees are best, offering summer shade but allowing the winter sun through.

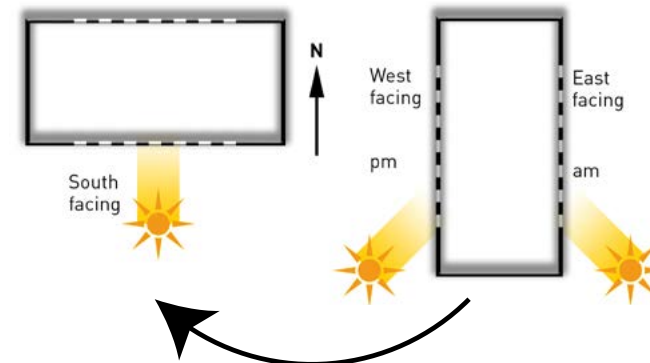


External blinds

External blinds can be used independently or with a fixed overhang/awning to offer more control of shading. Due to their lightweight frames, blinds are easier than heavier overhangs/awning to install on existing buildings, and can be manually controlled from inside the building.

Internal blinds tend to be less effective for reducing heat gain as, although they can reduce glare, the blind becomes hot within the room.

Figure 14 An illustration of issues of solar gain on building orientation



Doors

For many buildings easy access is essential, but open doors can allow uncontrolled quantities of air into a building, reducing comfort and wasting energy.

Behaviour change opportunities:

Keep doors closed

All external doors should be kept closed when heating or cooling systems are in operation. Consider fitting automatic closers to external doors and to internal doors separating areas with different requirements.

Fact:

Draught stripping is easy, inexpensive and improves occupant comfort. It can also reduce heating costs by up to 10% and can pay back any investment within a year or two.

Maintenance opportunities:

Fit brush strips

Fit the strips to the internal side of doors and windows. For gaps between double doors, select one door and add the brush strips.

Replace seals and door closers

Regular inspection and maintenance of draught proofing and door closers will ensure they continue to work properly and provide savings.

Seal unused doors

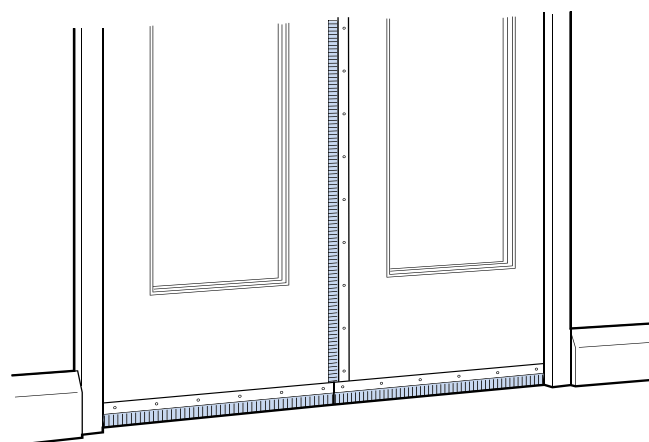
A quick and cheap action is to seal the perimeter of unused doors to avoid heat escaping and cold draughts entering a space.

Refurbishment opportunities:

Fit draught lobbies to main entrances

Installing a draught lobby at frequently used entrances can reduce heating costs and draughts. Ideally, a lobby should be large enough to ensure one set of doors is closed before the other is opened.

Figure 15 Brush strips



MYTH

Small gaps around doors do not let in much cold air.

REALITY

A door with a 3mm gap will let in as much cold air as a hole in the wall the size of a brick.

Install a revolving door

This is an alternative to a lobby, and reduces heat loss when people are entering or leaving the building. These doors should be draught-stripped. An ordinary door is necessary for emergency and disabled access, but should be kept closed when not in use.

Figure 16 Brush strips on a revolving door



Interlocking control for heating systems

Open doors can result in substantial heat losses. If heating turns off when doors are opened, heat loss is minimised and workers are incentivised to keep them closed. These are relatively cheap to install and particularly effective in loading bays, garages and workshops.

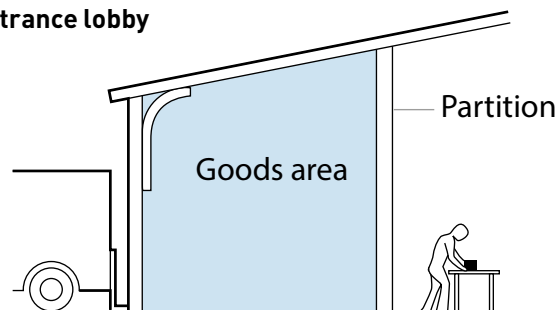
Vehicular access doors

Doors that provide access for vehicles are usually little more than large openings in a building's wall. This can result in large volumes of heat loss and uncomfortable working conditions.

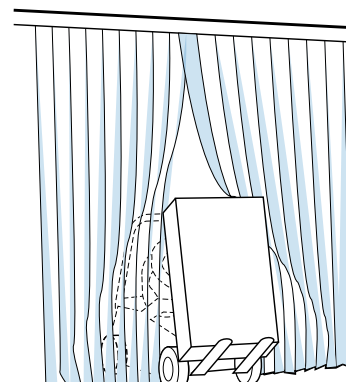
Heat losses can be mitigated through the use of a vehicle entrance lobby, PVC/plastic strip curtains or high speed motorised doors with automatic sensor controls.

Figure 17 Methods for keeping heat in when vehicle access is required

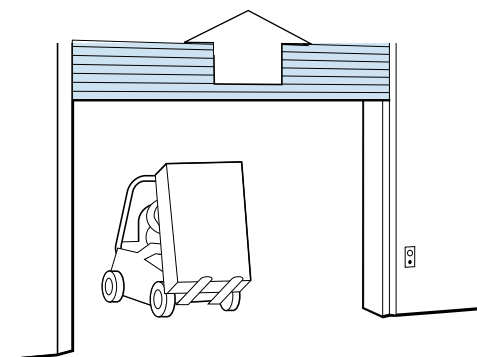
Entrance lobby



Plastic strip curtains



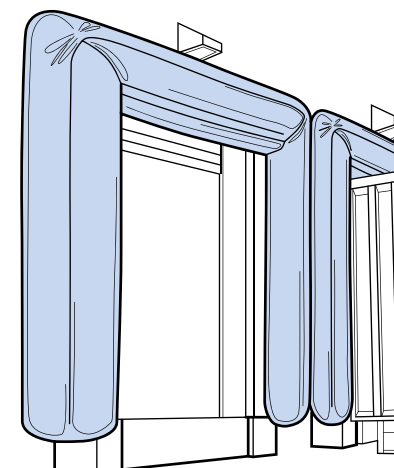
Fast-acting door



Airtight door seals

Insulating door seals allows goods trucks to reverse into an airtight seal and load/unload without compromising the heated or cooled air inside.

Example of airtight door seals



Floors

Floors are often overlooked as an area for energy saving, but nearly 10% of heat lost from a building will occur via the ground floor.

Maintenance opportunities:

Seal gaps and cracks

Sealing any cracks in flooring and around its edges is an easy and effective means of improving comfort and reducing costs. This is especially important in higher floors, where sealing cracks can reduce overheating from rising hot air.

The use of carpet, underlay or carpet tiles can also achieve this.

Refurbishment opportunities

Suspended timber floors

Adding insulation between joists, where there is access to the underside of suspended timber floors, is a cost-effective measure at any time. In cases where there is no access the process is much more difficult, and only worthwhile as part of a planned refurbishment. Floorboards can be lifted and the insulation can be suspended by a mesh before floorboards are re-laid.

To ensure optimal insulation, the following should be noted:

- Seal gaps at the skirting to avoid air infiltration.
- Maintain ventilation below the subfloor for timber floors.
- Place electrical cables sheathed in PVC in conduit, or protect from direct contact with expanded polystyrene insulation.
- Avoid placing heating pipes on the cold side of insulation, always ensure pipes are insulated.
- Install a vapour control layer to avoid condensation within the insulation if using mineral fibre or other non-hygroscopic insulation material.

Concrete ground floors

Opportunities for insulating existing solid ground floors are limited, adding insulation can only occur during floor replacement. There are three main options:

- Adding insulation prior to laying the final concrete surface.
- Installing insulation above the concrete slab.
- Adding insulation between the wooden battens supporting the floorboards.

All options are likely to be disruptive and expensive, likely only cost-effective during refurbishment. However, they will significantly improve thermal comfort.

Next steps

Here are six steps to implementing effective building fabric upgrades to reduce costs and improve the energy performance of your building:

Step 1: Understand your energy use

Look at your building and identify the major areas of energy consumption. Check the condition and operation of equipment and monitor the power consumption over say, one week to obtain a base figure against which energy efficiency improvements can be measured.

Step 2: Identify your opportunities

Walk round and complete an action checklist (see page 9 onwards) to identify where building fabric improvements can be made. Examine windows, doors, roof spaces, skirting and eaves to see whether they are draughty or damp. Further tips are available in 'Assessing the energy use in your building (CTL172)'.

Step 3: Prioritise your actions

Draw up an action plan detailing a schedule of improvements that need to be made and when, along with who will be responsible for them. Remember, you should improve building fabric standards before replacing HVAC systems to ensure they are optimally sized for maximum efficiency and cost savings.

Step 4: Seek specialist help

It is possible to implement some building fabric energy saving measures in-house, but others may require specialist help. These more complex measures often have long payback periods, and should be considered during planned refurbishment.

Step 5: Make the changes and measure the savings

Implement your energy saving actions and measures against original consumption figures. This will assist future management decisions regarding your energy priorities.

Step 6: Continue managing your building for energy efficiency

Enforce policies, systems and procedures to ensure that your organisation operates efficiently and that savings are maintained in the future.

Go online for more information

The Carbon Trust provides a range of tools, services and information to help you implement energy and carbon saving measures, no matter what your level of experience.

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👉 www.carbontrust.com/resources/tools/sme-carbon-network

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