Energy Efficiency Best Practice in Housing

Energy efficient garage conversions

This guide is intended to assist designers, builders and homeowners to incorporate Best Practice standards of energy efficiency into domestic garage conversions. It deals with:

- insulation of external walls, exposed floors and roofs;
- specifying energy efficient windows and external doors;
- providing efficient heating;
- providing controlled ventilation;
- specifying energy efficient lighting.

Two companion guides are also available: *Energy Efficient Domestic Extensions* (CE122) and *Energy Efficient Loft Conversions* (CE120).

ENERGY EFFICIENCY
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Contents

Introduction

In the UK, homes are responsible for approximately 28 per cent of carbon dioxide emissions, a major contributor to climate change. Domestic emissions arise from the use of energy for space and water heating, cooking, and the use of lighting and electrical appliances. To meet our international commitments and tackle climate change, we must significantly reduce energy related emissions in homes. By following Best Practice standards, new build and refurbished housing will be more energy efficient and will reduce these emissions, saving energy, money and the environment.

When a household requires more space or better accommodation, extending a home is a practical and cost effective alternative to relocation. Many households extend their homes by converting a garage, or part of a garage, to provide new accommodation such as a bedroom or study. Often the conversion of a garage is part of a larger extension project. Some homeowners engage architects to assist them with their garage conversions; others rely on reputable builders; a few design and carry out their garage conversions themselves.

A typical single garage provides space for a large study, or for one or two bedrooms, possibly with an ensuite bath or shower room. A garage conversion exploits the use of the existing construction, does not encroach on valuable garden space, and is usually much less expensive than building a completely new extension. In order to minimise additional fuel costs, and to ensure the new room or rooms will be comfortable all year round, it is important to insulate the converted garage to a good standard.

This guide is for architects, builders and homeowners who are engaged on garage conversion projects. It explains how to incorporate energy efficiency features into the design and specification of garage conversions, dealing with:

- insulation of walls, exposed floors and roofs;
- specifying energy efficient, high-performance windows;
- limiting thermal bridging and air leakage;
- providing controlled ventilation;
- providing efficient heating;
- specifying energy efficient lighting.

There are also two companion guides, *Energy Efficient Domestic Extensions* (CE122) and *Energy Efficient Loft Conversions* (CE120).

The importance of energy efficiency

Garage conversions are important because they can not only provide new, energy efficient accommodation but can also improve the overall energy efficiency of the original houses to which they are attached. For the homeowner, specifying an energy efficient conversion is a cost effective approach, because the additional cost (over what would have to be spent to meet the minimum requirements of the building regulations) is quickly recovered in reduced fuel costs. Payback periods are usually less than seven years, but fuel costs are reduced for the entire life of the building.

The three most important factors that contribute to energy efficiency are:

- the insulation and airtightness of the walls, floor and roof;
- the choice of fuel and the efficiency of the heating system;
- the efficiency of lights and electrical appliances.

Converting a garage

The process of converting a garage is similar to designing and building a home extension, and usually falls into the following stages.

1. Reviewing options and preparing an outline design.
2. Obtaining planning permission.
3. Preparing a detailed design and specification.
4. Obtaining approval under the building regulations.
5. Selecting a builder.
6. Constructing the conversion.

Opportunities for achieving a high standard of energy efficiency occur mostly at stage 3, when the detailed specifications for materials and products are prepared. At stage 6, the quality of the builder's work can have a significant impact on the effectiveness of the insulation and the degree of airtightness that is achieved, and these factors in turn will affect both energy efficiency and comfort.

It may be appropriate, when converting a garage, to consider improving the energy efficiency of the original house at the same time. For more information see *Energy Efficient Refurbishment of Existing Housing* (CE83).

Insulation

The building regulations impose minimum insulation standards for garage conversions, which are considered to be 'material alterations'.

The recommended Best Practice insulation standards (maximum U-values) set out in Table 1 provide for a better overall standard of insulation, thus reducing fuel use, fuel costs and carbon dioxide emissions. The cost of additional insulation may be offset against the savings from needing a smaller heating system (e.g. a smaller boiler and fewer, smaller radiators) resulting from the reduced heat loss.

Table 1: Recommended Best Practice elemental U-values for domestic garage conversions. The values for glazed openings (windows, doors and rooflights) are area-weighted averages for all the openings in the garage conversion.

Exposed element	Maximum U-value (W/m^2K)
Roofs	0.13
Walls	0.35 - 0.45
Floors	0.20
Windows, doors and rooflights	1.80

What are U-values?
A U-value is a measure of the overall rate of heat transfer under standard conditions, through a particular section of construction (units = W/m^2K). Lower U-values indicate better thermal insulation. For example, a wall with a U-value of $0.4W/m^2K$ loses heat at half the rate of a wall with a U-value of $0.8W/m^2K$.

Types of insulation

Three types of insulation are commonly used in garage conversions:

- rigid insulation;
- flexible insulation;
- thermal lining boards.

Rigid insulation is usually a form of plastic foam board, e.g. polyisocyanurate board. Examples of the flexible type are glass fibre and mineral fibre quilts. Thermal lining board usually consists of mineral wool or plastic foam insulation bonded to plasterboard, and containing an integral vapour check.

For a given thickness the rigid insulants usually have better insulating properties (i.e. lower thermal conductivity) than flexible types. For more information see *Effective use of insulation in dwellings: a guide for specifiers and contractors* (CE23).

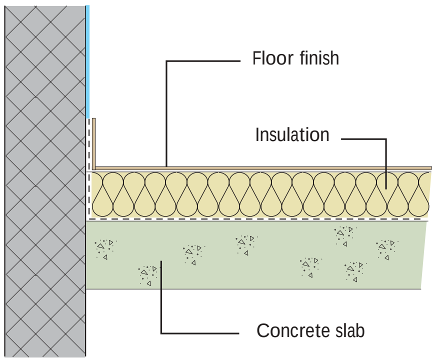
Insulating garage floors

When a garage is converted, the ground floor should be insulated to achieve the Best Practice U-value shown in Table 1 (i.e. to achieve a maximum U-value of $0.20W/m^2K$).

The ground floors of garages are usually concrete, typically a 'ground bearing' slab, but in some instances suspended, pre-cast concrete 'beam and block' units may have been used. The finished floor level is nearly always lower than that of the main house. Where the floor level is required to be raised, to bring it level with the house floor level, this presents an ideal opportunity to add insulation. This can be done in a number of ways but the more common methods are to:

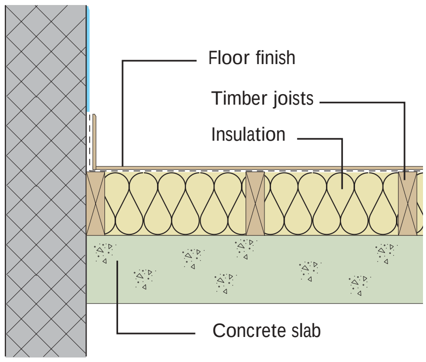
- lay rigid insulation on top of the existing concrete floor, and finish it with a concrete screed or timber boards;
- form a new suspended floor above the existing floor, using timber joists with insulation between them.

Figure 1: Insulating a garage floor above the concrete floor slab



A new suspended floor usually consists of timber joists with some form of boarded finish (e.g. chipboard, plywood, or tongue-and-grooved softwood boards). The joists can span between the walls of the garage, or bear on to the original concrete floor. Insulation, which can be either a rigid board or quilt type, is placed between the joists. If the joists are spanning between the walls the quilt type of insulation is usually suspended between them on proprietary plastic netting, which is itself stapled to the tops of the joists. Alternatively rigid board type insulation, cut to fit snugly between the joists, can rest on small timber battens which have been fixed to each side of the joists. These methods allow the thickness of the insulation to match the depth of the joists, resulting in good thermal performance.

Figure 2: Insulating a garage floor between suspended timber joists



When undertaking work to ground floors it is important not to block any ventilation openings, e.g. air bricks, to ventilated floor voids. It is also a good idea to include a polythene vapour barrier above the insulation, beneath the boarding, in order to reduce the risk of condensation occurring in the interstices of the new construction.

Insulating garage walls

When a garage is converted, exposed walls should be insulated to achieve the Best Practice U-value shown in Table 1 (i.e. to achieve U-values between $0.35W/m^2K$ and $0.45W/m^2K$). Existing walls can be insulated in one of three ways: externally, usually with a render finish; internally, behind plasterboard linings; or, if the walls are of cavity construction, by filling the cavity with insulation.

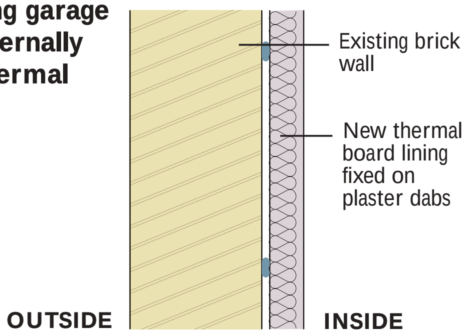
External wall insulation can be costly, but is often appropriate if the wall requires remedial action, for example, to combat dampness, or where an existing render finish needs to be replaced. Proprietary external insulation systems typically consist of rigid insulation board or semi-rigid mineral fibre insulation mechanically fixed to the wall, with a high performance render coating over the insulation. Further information appears in *External insulation systems for walls of dwellings* (GPG293).

If the existing wall is of cavity construction and the cavity is not already insulated, it may be insulated by blowing mineral fibre or plastic bead insulation into the cavity. This is a specialist operation that involves drilling holes in the brickwork at approximately one metre spacing (horizontally and vertically), then blowing-in insulation material to fill the void. This work may be carried out from the inside of the garage, before any plaster or linings are fixed, so the external appearance of the garage need not be affected. Further information appears in *Cavity wall insulation in existing housing* (CE16).

The most common form of external wall construction for existing garages is solid masonry (brickwork and/or blockwork). Typically, walls consist of 113mm thick 'single' brickwork, with occasional piers to provide stability. This form of construction lends itself to placing the insulation internally, and this is the easiest and most cost effective method of the three, often referred to as 'dry-lining'. There are however some disadvantages to internal insulation: there will be a small loss of internal space, and fixing heavy items such as kitchen cupboards to the walls can be difficult.

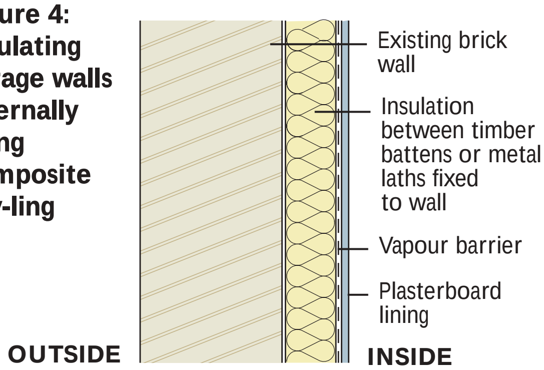
There are two methods of insulating a wall internally: fix a proprietary insulating lining board; or fix a metal or timber framing system to the wall, place insulation between the framing members and then finish the wall internally with plasterboard.

Figure 3: Insulating garage walls internally using thermal board



Perhaps the easiest method of dry-lining a wall is to fix a proprietary insulating board to the inside of the wall. The board consists of a layer of plasterboard bonded to a layer of rigid insulation. It can be fixed to the wall mechanically or (more usually) by plaster dabs.

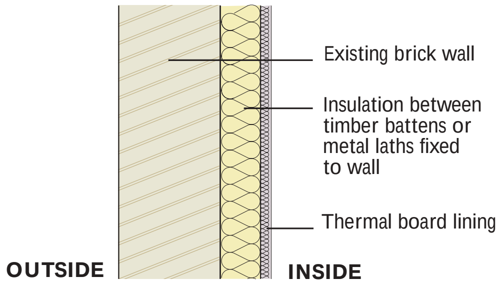
Figure 4: Insulating garage walls internally using composite dry-ling



The alternative, composite method is to fix galvanised steel laths or timber battens to the wall, place insulation between them, and then line them with plasterboard. This approach can achieve a better standard of insulation than proprietary lining boards, but at the expense of space taken from the room. Insulation is usually 50mm thick, but up to 100mm of insulation can be included. Note that the insulation is 'bridged' by the framing. This problem can be dealt with by combining the two methods of dry-lining. This method will deliver better thermal performance, consistent with Best Practice standards.

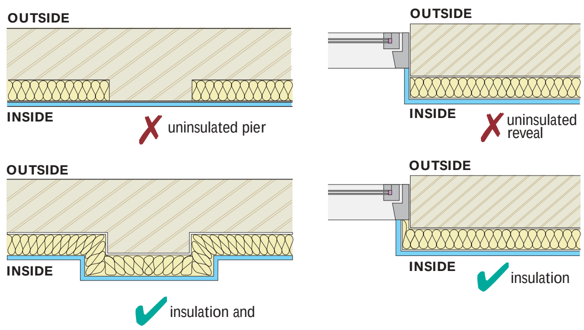
Whichever dry-lining method is used, it is very important to seal the edges and joints in the lining board (and any service penetrations such as electrical switches and sockets) in order to prevent warm, moist air penetrating behind the lining, resulting in hidden condensation on the cold masonry surface. Sealing should be carried out with tape and/or a skim of wet plaster, before the linings are painted.

Figure 5: Combining dry-lining methods



There are several other techniques for reducing thermal bridging of the insulation, and the consequent risk of surface condensation. Where the walls have attached piers, the insulated lining should be taken around them rather than simply butting up to the pier at each side. The insulation should also be taken into the reveals and soffits of door and window openings, and beneath window cill boards.

Figure 6: Avoiding thermal bridging at wall piers and at window and door openings



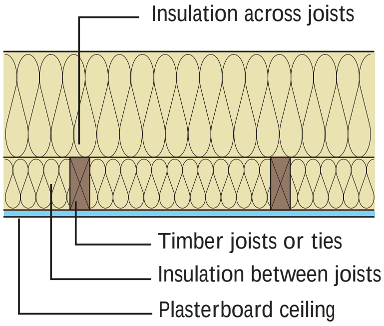
Insulating garage roofs

An existing garage may have a pitched or a flat roof but both types will usually be uninsulated. Roofs should be insulated to achieve the Best Practice U-value shown in Table 1 (i.e. to achieve maximum U-values of 0.13W/m^{2}K).

If the existing roof is of pitched construction (consisting of a timber structure supporting roofing felt and tiles or slates), and a new ceiling is to be installed, then the easiest way to insulate is to place mineral fibre quilt between the timber ties (or ceiling joists). The insulation can be supported by a new plasterboard ceiling. It is important to maintain a flow of air in the roof void, above the insulation, to prevent condensation forming. If the roofspace is to be used for storage, bearer boards should be placed across the existing joists, to prevent the insulation from being compressed.

For more information see *Effective use of insulation in dwellings: a guide for specifiers and contractors* (CE23).

Figure 7: Insulating a garage roof at ceiling level



If the intention is to expose the shape of the original roof internally (i.e. to create higher rooms, without roofspaces above them) then rigid insulation can be placed between the existing rafters. Polythene vapour barriers and plasterboard linings can then be fixed beneath the rafters. However, it is essential to maintain a flow of air over the insulation, beneath the roofing felt and tiles, in order to reduce the risk of interstitial condensation. The building regulations specify that a 50mm wide ventilation gap must be maintained, so the thickness of the insulation cannot exceed 50mm less than the depth of the rafters, and this may make it difficult to achieve the recommended Best Practice U-value.[1]

If the existing rafters are not deep enough to contain sufficient insulation to achieve the recommended Best Practice U-value (plus the 50mm ventilation gap) there are two other options:

- supplement the insulation between the rafters by using a thermal board, instead of ordinary plasterboard, for the internal ceiling lining; or
- adopt a form of construction called a 'vapour balanced' or 'breathing' roof.

These options may be combined.

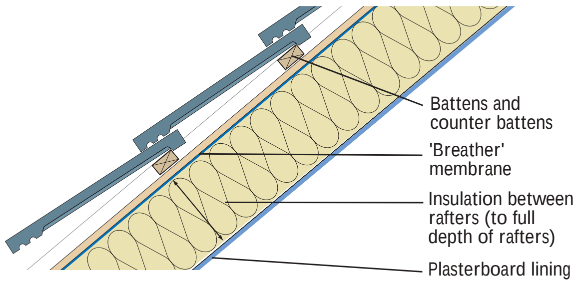
1 Proprietary soffit ventilators must also be installed at eaves level, to admit ventilation air, and at the ridge or abutment of the roof, to permit the air to escape.

Vapour balanced 'breathing' construction

A vapour balanced roof construction is one through which moisture is allowed to permeate, removing the need for ventilation of the roof construction. The impervious roofing felt is replaced by 'breather felt', and the 50mm ventilation gap, the soffit and ridge ventilators and the polythene vapour barrier are all omitted. This simplifies the construction and leaves more space for the insulation. However because the existing roofing felt must be replaced by the special vapour-permeable type, the existing slates or tiles, and the tiling battens, must all be removed and replaced as part of the conversion.

If an existing roof is flat then there are several options and opportunities for adding insulation. The waterproof covering of a flat roof has a limited life, usually between fifteen and twenty years. If an existing garage roof is in need of repair or replacement then converting the garage provides a good opportunity to look at the options.

Figure 8: Insulating a garage roof using vapour-balanced construction



One option is simply to re-roof the area, leaving the existing timber structure in place and adding insulation between the roof timbers. This type of construction is called a 'cold' roof, and must be ventilated above the insulation (and beneath the external roof deck and finish) in order to reduce the risk of interstitial condensation. Very few roofs are constructed in this way because cold roofs are very difficult to ventilate adequately. Cold roof construction is not recommended.

A 'warm roof' construction is one that has the insulation above the timber structure, with the waterproof external finish layer bonded directly to it. This is the most common type of insulated flat roof.

Another option is to change the flat roof to a pitched roof. Some householders see this as a more aesthetically pleasing solution, which also significantly reduces the need for regular maintenance. The change can be made relatively easily, but it depends on the supporting structure (the existing walls, and their foundations) being able to carry the extra weight.

Advice should be sought from a consultant structural engineer before this approach is adopted.

Figure 9: 'Cold' insulated flat roof construction

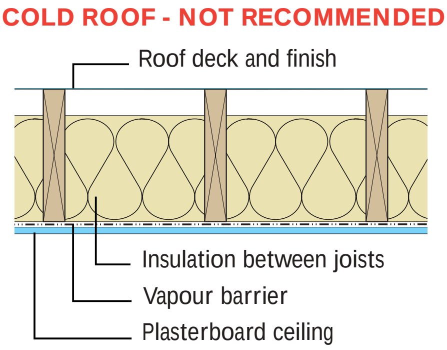
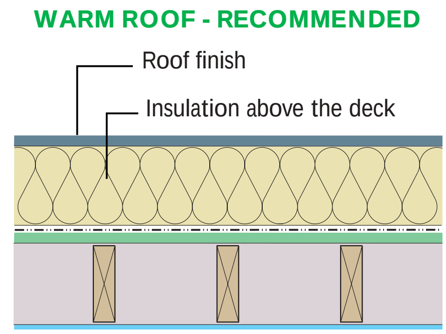


Figure 10: 'Warm' insulated flat roof construction



Glazed openings

Glazed openings (windows, roof windows and glazed doors) fulfil multiple functions. They provide views out, let daylight in and assist with ventilation. However, the heat loss through one square metre of a modern, high-performance double-glazed window is much greater than the heat loss through one square metre of insulated external wall or roof. Excessive glazing is therefore a cause of unnecessary heat losses.

However, inadequate glazing (i.e. windows that are too small) can lead to rooms being gloomy. If occupants feel the need to switch on lights during the day then fuel use, fuel costs and carbon dioxide emissions will all be increased.

For garage conversions, the building regulations in each part of the UK specify maximum areas of glazed openings allowed (windows, doors and roof windows). In England and Wales the requirement is that the total area of windows, doors and rooflights must not exceed 25 per cent of the floor area of the new accommodation. Or, the area of openings in the enlarged dwelling (i.e. the original house plus the converted garage) must not exceed the area of openings in the original dwelling. Or, the total area of the glazed openings in the enlarged dwelling must not exceed 25 per cent of the floor area of the enlarged dwelling. The requirements differ in Scotland and Northern Ireland.

This is an important consideration if the original garage door is to be replaced. The area of a single garage door is approximately $4m^2$, and the floor area of a single garage is usually between $12.5m^2$ and $18m^2$, so replacing the whole of the garage door with glazing will often exceed the maximum permitted glazed opening area[2]. It is preferable to fill the door opening with new external wall (insulated to the Best Practice standard in Table 1), and to incorporate a conventionally sized window to provide daylight, ventilation and views out. Timber-framed walls, incorporating insulation between the framing members, are often used to replace garage doors. They are finished internally with plasterboard or thermal board, and externally with timber weatherboarding or render.

The building regulations also specify maximum thermal transmittances (U-values) for new openings (windows, doors and rooflights. Adopting the better Best Practice standards for openings shown in Table 1 (i.e. maximum U-values of 1.8W/m2K) will reduce fuel use, fuel costs and carbon dioxide emissions associated with heating the converted garage. There are many possible combinations of frame and glazing types for new openings. Examples of window types that meet the Best Practice standards are as follows.

- Timber-framed windows with double glazing incorporating at least a 16mm glazing gap, argon gas fill and one 'soft' low emissivity coating.
- Timber-framed windows with triple glazing, 12mm glazing gaps, and one 'hard' low emissivity coating.
- Metal-framed windows (incorporating thermal breaks) with triple glazing incorporating at least 16mm glazing gaps, argon gas fill and one 'soft' low emissivity coating.

Low emissivity coatings

Low emissivity ('low-e') coatings for glazing are of two main types, known as 'hard' and 'soft'. The soft coatings provide better performance at little additional cost.

Gas filling

The most common form of gas filling for double and triple glazing is argon. Better performance can be obtained (at higher cost) by filing with krypton or xenon.

All windows and external doors must be weather-stripped, and should be equipped with good-quality locking mechanisms that ensure that the seals are compressed when they are closed.

2 Similarly, the area of a double garage door is approximately 8 m^2, and the floor area of a double garage is usually between 25 m^2 and 30 m^2, so replacing the whole of the garage door(s) with glazing will often exceed the maximum permitted glazed opening area.

Window energy ratings
The British Fenestration Rating Council (BFRC) Window Energy Label provides an objective standard against which the relative merits of different window types for a home extension can be judged. Selecting A or B rated windows also ensures that the windows achieve the manufacturer's claimed performance, and that air leakage and draughts are kept to a minimum. Since February 2005 Band C and above windows are Energy Efficiency Recommended by Energy Saving Trust (EST).

For more information see *Windows for New and Existing Housing: a summary of Best Practice* (CE66) and *Benefits of Best Practice: Glazing* (CE14).

Ventilation

In the UK, domestic buildings have traditionally relied on air infiltration through the building fabric to provide background ventilation. This is supplemented by extract ventilation fans or by opening windows when additional ventilation is required.

Modern construction methods and regulations deliver a higher standard of airtightness, and it is no longer acceptable to rely on infiltration to provide background ventilation. The maxim is 'build tight, ventilate right'. In garage conversions, the provision of appropriate, controlled ventilation is therefore essential, in order to ensure good air quality and avoid the risk of surface condensation. However, excessive ventilation results in unnecessary heat loss, and consequently increased fuel use, fuel costs and carbon dioxide emissions.

Ventilation falls into three main types.

- Background ventilation - provided by air bricks, trickle ventilators in window heads, or facilities to secure windows slightly open in a 'slot ventilation' position.
- Rapid or 'purge' ventilation - provided by opening windows, when there is a need to expel pollutants or admit fresh air.
- Extract ventilation - provided to expel moist stale air from 'wet areas' (i.e. kitchens, bathrooms and utility rooms) in order to reduce the risk of surface condensation.

Minimum requirements for each type of ventilation are set out in the building regulations for each part of the UK.

Energy efficient ventilation is achieved by providing ventilation only when and where it is needed. Wet areas must be provided with extract ventilation, in the form of electric fans or 'passive stack ventilation'.

Extract ventilation fans should be controlled by humidistats, or wired to operate with light switches (with timed 'run-on').

Energy efficient, low power fans incorporating DC motors are now available. Fans of this type reduce the fuel use, fuel costs and carbon dioxide emissions associated with providing ventilation.

Heat recovery room ventilators (HRRVs) combine supply and extract fans in a single 'through the wall' unit. Extracted warm stale air is passed over a plastic cross-flow heat exchanger where heat in the air is transferred to the cool, fresh external air that is supplied to the room. HRRVs reduce the heat loss penalty associated with electric ventilation fans.

For more information see *Energy-efficient ventilation in housing: a guide for specifiers on the requirements* and *options for ventilation* (GPG 268).

Passive stack ventilation
If the converted garage has a pitched roof and includes a bathroom or kitchen it may be appropriate to provide extract ventilation by means of passive stack ventilators. These consist of vertical plastic ducts that connect ventilation grilles at ceiling level in 'wet spaces' to terminals on the roof of the building. Warm moist air rises up these ducts because of its natural buoyancy (assisted by wind blowing across the roof) and is replaced by fresh air that enters via trickle ventilators in window heads elsewhere. Passive stack ventilation is silent, and thus especially good for ensuite bathrooms, but it only works well when the terminals are located at or near the highest point of the roof (usually the ridge), so this form of ventilation will not always be appropriate for garage conversions, especially those which have flat roofs, or 'lean to' pitched roofs on one side of the original house.

Heating

Boiler capacity

For houses equipped with gas- or oil-fired central heating, one of the key issues associated with a garage conversion is whether the existing boiler has adequate capacity to heat the enlarged house. In many cases, the additional heat loss associated with the conversion makes it necessary to install a new boiler with appropriate additional capacity, at significant cost.

However, in some cases a well insulated garage conversion may reduce the overall heat loss of the house (by covering up some of the original, less well insulated walls) or leave it almost unchanged, so that a new boiler is not needed. Sometimes the boiler in the original house has been over-sized, and it may be able to cope perfectly adequately with an increase in heat loss in the order of 10 per cent. It is therefore worth calculating the effect of the proposed conversion on the heat loss of the house, at an early stage of the design. Adopting the recommended Best Practice U-values in Table 1 will reduce the heat loss of the conversion, and may help to avoid a requirement for a new boiler, thus reducing the overall cost of the project.

For more information see the CIBSE *Domestic Heating - Design Guide*.

Replacement boilers

If a new boiler is required, the UK building regulations require that it achieves a minimum seasonal efficiency. Further to this, from 1 April 2005, all gas boilers installed in England and Wales are required to be condensing boilers (aside from a small number of exceptions). The Best Practice standard is to install a boiler of seasonal efficiency grade A or B (i.e. at least 90 per cent).[3] In addition, if the boiler is replaced the building regulations require that:

- the existing heating system must be upgraded to 'fully pumped' circulation (i.e. not 'gravity feed') if it is not already fully pumped;
- the heating controls must be upgraded to include a programmer, a room thermostat and a thermostat on any hot water storage cylinder;
- the room thermostat must be 'interlocked' to the boiler so that the boiler does not fire when there is no demand for heat.

Rooms without internal or solar heat gains (i.e. bathrooms, and rooms with south-facing glazing) should also have responsive heating controls such as thermostatic radiator valves (TRVs), so that the heat input is reduced when 'free' heat gains are available instead. This improves efficiency and reduces the risk of overheating.

Condensing boilers

The most efficient type of boiler is the condensing boiler, which is becoming the standard type of boiler in most parts of the UK. Further to this, from 1 April 2005, all gas boilers installed in England and Wales are required to be condensing boilers (aside from a small number of exceptions).

Condensing boilers have larger heat exchangers than regular boilers, and achieve seasonal efficiencies between 86 and 91 per cent. The efficiency of a condensing boiler remains high even when it is working at a low level of output (e.g. providing hot water only, in summer).

Where a new boiler is required to cope with the additional heat load of a garage conversion, the improved efficiency obtained from a condensing boiler (compared with an original, conventional boiler) will often offset the additional demand, resulting in little or no increase in fuel cost.

For more information on heating and controls, see *Central heating system specifications (CHeSS)* year 2005 (CE51), *Domestic heating by gas: boiler systems* (CE30) and *Domestic heating by oil: boiler systems* (CE29).

Room heaters

Where the house whose garage is being converted does not already have central heating, it is a good idea to consider the installation of a central heating system, with a condensing boiler, as part of the conversion project. However, if this is not appropriate or affordable the conversion may be equipped instead with one or more fixed individual room heaters.

There are several types of room heaters, which run on gas, electricity or solid fuel[4]. Better types of room heaters are equipped with time and temperature controls. Unless it is electric or has a balanced flue, a room heater must have a supply of combustion air brought into the room from outside.

Natural gas heaters include wall-mounted models as well as traditional open hearth and fireplace installations. Wall-mounted heaters provide more flexibility of siting within the room, depending on the type of flue. Some models must be fitted on an external wall, but others can be fitted on an internal wall with the flue routed to an external wall. The efficiencies of natural gas heaters vary. Some decorative 'open-basket' focal-point heaters have efficiencies as low as 20 per cent, but the efficiencies of closed radiant convector heaters (including some with the popular coal effect) can be 75 per cent or more.

Electric room heaters such as panel heaters, convector heaters and radiant heaters are 100 per cent efficient (all the energy in the electricity is turned into heat in the room) but they are very expensive to run because they use on-peak electricity, and the associated carbon dioxide emissions are high. Wherever possible, these heaters should be equipped with programmers or time-clocks, and thermostatic controls.

Solid fuel room heaters include open and closed solid fuel fires with and without back boilers (to provide hot water), and free-standing solid fuel stoves. Closed room heaters (with glass doors) and stoves are much more efficient than open fires. In most urban areas only smokeless fuels may be used.

Using a gas-fired room heater to heat a garage conversion will involve much lower carbon dioxide emissions than using an electric heater. However, using a wood-burning stove (burning wood chips, wood pellets or logs) involves little or no carbon dioxide emissions.

Lighting

In most homes, lighting accounts for between 10 and 15 per cent of the electricity bill, and contributes significantly to carbon dioxide emissions. The building regulations in England and Wales require that new accommodation (including garage conversions) includes some light fittings that will only accept energy efficient lamps. At least one new room in three should be equipped with such fittings.

- There are two types of energy efficient lamps - fluorescent tubes; and compact fluorescent lamps (CFLs).
- Modern CFLs can provide good lighting effects. A large range of types is available, including spot lamps, candle lamps, and coloured lamps of every description.
- Energy efficient lighting is most cost effective in rooms where the lighting is frequently used. Any room in which the lighting is used for more than four hours each day should be considered.
- Installing energy efficient lighting in a garage conversion can provide savings of over £50 per lamp, over the life of each lamp, even though energy efficient lamps are initially more expensive than conventional ones.

3 The seasonal efficiency (and efficiency grade) of any gas- or oil-fired boiler available in the UK may be obtained from the public boiler efficiency database at www.boilers.org.uk.
4 Portable bottled gas and paraffin heaters are not recommended because they have no chimney or flue for exhaust gases to escape through. Substantial ventilation (involving significant heat loss) must be provided to remove carbon dioxide and water vapour, otherwise there is a significant risk of surface condensation and/or asphyxiation of the occupants.

Lighting should be designed according to the use of the room, and should be considered carefully. Properly designed energy efficient lighting can improve the 'feel' of a room as well as saving energy.

For more information see *Energy Efficiency Primer* (CE101), *Cost benefit of lighting* (CE56), *Low energy domestic lighting - summary guide* (CE81), *Energy efficient lighting - a guide for installers and specifiers* (CE61) and *Domestic lighting innovations* (CE80).

Energy Efficiency Recommended

The Energy Saving Trust (EST) manages a labelling scheme for products of proven energy efficiency. The scheme currently covers appliances (washing machines, fridges, freezers, dishwashers and tumble dryers), light bulbs and fittings, gas and oil boilers, heating controls, loft insulation, cavity wall insulation, draught-stripping, external wall and dry linings, high performance hot water cylinders and windows. These products carry the Energy Efficiency Recommended label. Currently endorsed products can be found at www.est.org.uk/myhome.

Energy Efficiency Recommended logo

Questions and answers

Convert or extend?

Q Is it better to convert my garage, or build an extension?

A This depends on your circumstances. Garage conversions are usually less costly than extensions, and they don't take up garden space, but of course the garage accommodation is lost.

Insulation

Q Will the converted garage have to be insulated?

A Yes, garage conversions are treated as 'material alterations', and Part L1 of the building regulations specifies insulation standards for exposed walls and floors, for roofs and for new windows and doors.

Q How much insulation should I include?

A Adopt the Best Practice insulation standards set out in Table 1. This will reduce heat losses, and thus reduce fuel use, fuel costs and carbon dioxide emissions. The cost of the extra insulation can be offset by having a smaller heating system, and it may be possible to retain the existing boiler.

Q Is insulation always effective?

A Yes, if it is properly installed. Make sure that your architect and builder understand the need to eliminate 'thermal bridges' and to achieve a good standard of airtightness. There should be no gaps in the insulation at the junctions of walls, roofs and floors, or around openings. Windows and doors should be properly sealed into the walls, and the places where services (pipes and wires) penetrate through walls and floors should also be sealed.

Q The garage has solid walls - how can they be insulated?

A There are several options including external insulation (which usually has a rendered finish) and internal insulation behind new plasterboard linings.

Q What about the pitched roof?

A The roof can be insulated between the existing rafters, or a new insulated ceiling can be constructed (creating a new roofspace).

Q What about the flat roof?

A The best option is a 'warm roof' construction incorporating insulation above the decking and beneath a new roof finish. The alternative 'cold roof' construction incorporating insulation beneath the decking, between the existing joists, is not recommended.

Glazed openings

Q I would like to have large windows. Is this a good idea?

A No, windows contribute significantly to heat losses, and thus to fuel use, fuel costs and carbon dioxide emissions. Windows should only be large enough to admit adequate daylight, and the area of north-facing windows should be minimised.

Q What about south-facing windows?

A South-facing windows do trap some useful solar gains, but they also contribute to summer overheating. South-facing glazing should be shaded from high-angle summer sun, and highly-glazed south-facing rooms must be well ventilated.

Q Should I specify high-performance glazing?

A Yes, double- or triple-glazing with wide gaps, a low emissivity coating and gas filling will reduce heat losses, and thus reduce fuel use, fuel costs and carbon dioxide emissions. It will also improve comfort by reducing down-draughts and the risk of internal surface condensation.

Ventilation

Q Does the converted garage have to be ventilated?

A Yes, there must be provision for background, rapid and (in 'wet areas') extract ventilation. Trickle ventilators and openable windows meet most of this requirement. For wet areas, there are several controlled ventilation options, including energy efficient extract fans, heat recovery room ventilators and (for some extensions) passive stack ventilation.

Heating

Q Will the existing heating boiler have to be replaced?

A Not necessarily. If the converted garage is well insulated and airtight there may be little or no overall increase in heat loss, and the spare capacity in the existing boiler may be sufficient. This can be confirmed by calculation.

Q What if the existing boiler is not adequate?

A The existing boiler should be replaced by a new condensing boiler, of appropriate output and seasonal efficiency grade A or B. If you install an efficient, condensing boiler, the improved efficiency will offset the additional heat demand, so fuel costs will not necessarily increase significantly.

Q Will I have to upgrade my heating controls?

A If you don't already have good controls, and you replace the boiler, yes, you will have to upgrade. The upgraded system must be fully-pumped, and include a programmer, room thermostat and hot water cylinder thermostat. The room thermostat must be interlocked to the boiler so that the boiler does not fire when there is no demand for heat.

Q Should I include a room heater in the converted garage?

A An efficient gas-fired room heater or a wood-burning stove is sometimes a good alternative or supplement to extending or installing central heating. Electric room heaters are efficient, but they are also expensive to run and have high carbon dioxide emissions. Wood-burning room heaters have no associated carbon dioxide emissions.

Lighting

Q What type of lighting should I install?

A Energy efficient lighting with compact fluorescent lamps (CFLs) is much less expensive (over the life of the lamps) than conventional tungsten lighting, even though the energy efficient lamps are more expensive initially. Energy efficient lighting significantly reduces electricity use and the associated carbon dioxide emissions.

Q How can I achieve the desired lighting effect with CFLs?

A A large range of CFL lamp types is available, including spot lamps, candle lamps, and coloured lamps of every description. The multi-tube lamps light up instantly, and quickly reach their full brightness. Special dimmer switches are available for use with CFLs.

Professional assistance

Q Who can help me with all this?

A Choose your architect and builder carefully. Ask them if they know how to design energy efficient domestic extensions, and whether they have completed any. Ask them if they are familiar with this guide, and with the other guides listed below. If in doubt, contact your local Energy Efficiency Advice Centre (EEAC) via the Energy Saving Trust's **Energy Efficiency Helpline** on **0845 727 7200.**

Further information

Energy Efficiency Best Practice in Housing

The following Energy Efficiency Best Practice in Housing publications are available free by telephoning the Helpline on 0845 120 7799 or by visiting the website at: www.est.org.uk/bestpractice.

Energy efficient loft conversions (CE121)
Energy efficient garage conversions (CE120)

General

Energy efficiency primer (CE101)
Achieving Best Practice in new housing: a practical guide (CE95)
Building your own energy efficient house (CE123 / GPG194)
Energy efficiency in new housing: England Wales and Scotland (CE12)
Energy efficiency in new housing: Northern Ireland (CE24)
Energy efficient refurbishment of existing housing (CE83)
The effect of the Building Regulations, (Part L1 2002) on existing dwellings - information for installers and builders for extensions and alterations in England and Wales (CE53)

Insulation

External insulation systems for walls of dwellings (GPG 293)
Cavity wall insulation in existing housing (CE16)
Effective use of insulation in dwellings: a guide for specifiers and contractors (CE23)
Insulation materials chart: thermal properties and environmental ratings (CE71)

Windows

Windows for New and Existing Housing: a summary of Best Practice (CE66)

Airtightness

Improving airtightness in existing housing (GPG224) (GPG 224)

Ventilation

Energy-efficient ventilation in housing: a guide for specifiers on the requirements and options for ventilation (GPG268)

Heating

Domestic heating by gas: boiler systems guidance for installers and specifiers (CE30)
Domestic heating by oil: boiler systems guidance for installers and specifiers (CE29)
Domestic heating: solid fuel systems guidance for installers and specifiers (CE47)
Central heating system specifications (CHeSS) year 2005 (CE51)

Lighting

Low energy domestic lighting - looking for less (CE81)
Low energy lighting - a summary guide (GIL20)

Other publications

The Building Regulations 2000, Approved Document L1, Conservation of Fuel and Power, The Stationery Office, London, 2001.

The Building Standards (Scotland) Regulations 1990, 6th amendment: Technical Standards to Part J, Conservation of Fuel and Power.

The Building Regulations (Northern Ireland) 1994, Technical Booklet part F, Conservation of Fuel and Power (1998).

Limiting thermal bridging and air leakage: robust construction details for dwellings and similar buildings, DEFRA and DTLR, The Stationery Office, London, 2002.

CIBSE *Domestic Heating - Design Guide,* Chartered Institute of Building Services Engineers, London 2003.

Anderson J and Howard N *The Green Guide to Housing Specification,* published for the Building Research Establishment by Construction Research Communications Ltd, London, 2000.

CE121

Energy Efficiency Best Practice in Housing

Energy efficient garage conversions

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