Energy Efficiency Best Practice in Housing

Energy efficient domestic extensions

This guide is intended to assist designers, builders and homeowners to incorporate Best Practice standards of energy efficiency into home extensions. 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 Loft Conversions* (CE120) and *Energy Efficient Garage Conversions* (CE121).

Energy Efficiency — Save Energy Money Environment
Energy Saving Trust

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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 often a very practical and cost effective alternative to relocation. Extensions can be designed to suit the location of the house (exploiting views, making good use of daylight, etc) and to provide the precise accommodation that the household requires, in the best arrangement. However, building an extension involves a significant investment of time and money, and the resulting accommodation will probably remain in use for at least sixty years, so it is important to design to a good standard. Many homeowners engage architects to assist them with the designs of their extensions; others rely on reputable builders; a few design and construct their extensions themselves.

This guide is for homeowners, designers and builders to use together. It explains how to incorporate Best Practice energy efficiency features into the design and specification of domestic extensions, and deals with:

- energy efficient extension shapes;
- insulation of external 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 Loft Conversions* (CE120) and *Energy Efficient Garage Conversions* (CE121).

The importance of energy efficiency

Home extensions are important because they can not only provide new, energy efficient accommodation but can also improve the overall energy efficiency of the houses that are extended. For the homeowner, specifying an energy efficient extension 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 as follows.

- The insulation and airtightness of the exposed walls, roofs and floors; good insulation and airtightness reduce heat loss.
- The choice of fuel and the efficiency of the heating system; this affects the amount of fuel required to satisfy the heat loss.
- The efficiency of lights and electrical appliances; this affects the demand for electricity (which is not only expensive but also involves significant carbon dioxide emissions).

Designing and building an extension

The process of designing and building a home extension 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 extension.

Opportunities for achieving a high standard of energy efficiency occur mostly at stage 3, when the detailed specifications for materials and products are prepared. However, there are also opportunities at stage 1, because the overall form of an extension influences its energy efficiency. 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.

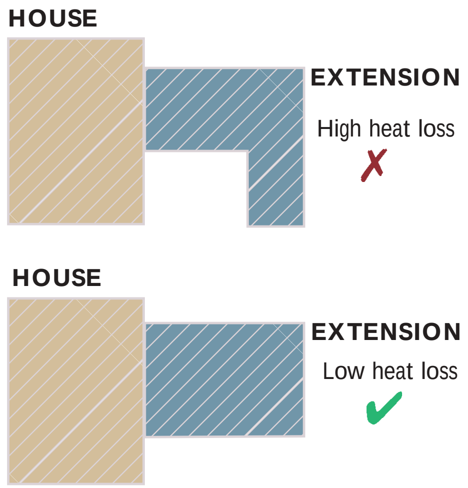
It may be appropriate, when extending a house, to consider improving the energy efficiency of the original house at the same time. For more information see *Energy Efficient Refurbishment of Existing Housing* (CE83).

Energy efficient extension shapes

Overall form

Homes and home extensions take many forms. They contribute to the rich architectural variety we find in our villages and towns. However, when planning an extension it is important to bear in mind that some forms are inherently more energy efficient than others. The most efficient forms reduce heat losses by reducing the ratio of heat loss area (i.e. the area of exposed walls, roofs and floors) to floor area. This is illustrated in Figure 1.

Figure 1: The influence of the form of an extension on heat losses



Unless the site dictates otherwise, it is a good idea to make the extension as compact as possible. A two-storey extension is inherently more efficient than a single-storey extension. Very elongated or elaborately shaped extensions should be avoided (as far as possible) because they will result in more heat loss and thus higher heating costs per unit of new floorspace. For the same reason, it is advisable to avoid very complicated shapes involving wings, bays, dormers, etc. Where the form of the extension is unavoidably complicated, consider adding extra insulation to compensate for the additional heat losses.

An extension with some south-facing pitched roof will permit the use of renewable energy technology such as solar water heating or photovoltaic (PV) panels to generate electricity. These will significantly reduce carbon dioxide emissions. The capital cost of solar PV systems are quite high but falling steadily. The cost of installing solar PV can also be recouped through reduced fuel bills and by selling surplus generated electricity to your electricity supply company (via a 'net metering contract'). For more information see *Renewable energy sources for homes in urban environments* (CE69) or *Renewable energy sources for homes in rural environments* (CE70) and *Integrating new and renewable energy technologies into existing housing* (CE102).

Glazing

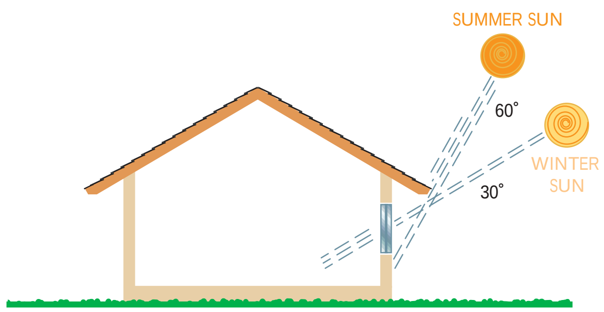
Another important factor is the amount and orientation of glazed openings (windows, roof windows and glazed doors). Windows fulfil several functions: they provide views out, let daylight in and assist with ventilation. However, the heat loss through one square metre of a modern, high-performance double-glazed window is nearly six times greater than the heat loss through one square metre of new external wall, and between ten and twelve times greater than the heat loss through one square metre of new insulated roof.[1] Consequently, the building regulations in each part of the UK specify maximum areas of glazed openings (windows, doors and roof windows) in an extension.

Where glazed openings have a southerly orientation (south ± 30°) they can trap some useful solar heat gains on sunny days during the heating season. At other times the openings will contribute to heat losses; and in the summer, unless they are shaded, they may contribute to solar overheating. Glazed openings with northerly orientations increase heat losses (compared with an equivalent area of wall) without trapping any compensating solar gains.

Excessive glazing is therefore a cause of unnecessary heat losses, and excessive southerly glazing can result in spaces not only being difficult and expensive to heat in winter but also uncomfortably hot in summer. Rooms with southerly orientations should be designed with shaded glazing (to exclude high-angle summer sun) and good ventilation (to remove summer heat gains).

Remember, however, that 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, fuel use, fuel costs and carbon dioxide emissions will all be increased. Therefore an energy efficient extension will include an appropriate amount of glazing, and the proportion of glazing on sides facing in different directions will need to be different.

Figure 2: Shading of glazed openings against high-angle summer sun, by over-hanging eaves



Conservatories

Conservatories seem to offer inexpensive accommodation with the bright, 'airy', almost external feel of a highly-glazed space. However, solar heat gains are more than offset by the high rate of heat loss through glazing, especially if the conservatory does not have a southerly orientation (± 45°). An unheated, southerly-oriented, highly-glazed conservatory will provide comfortable accommodation during spring and autumn, and on a few sunny days in winter. At other times in the winter it will be cold, and in the summer it will overheat. Comfortable periods can be extended by the use of shading, blinds and ventilation, but conservatories should never be heated because this leads to excessive fuel use, fuel costs and carbon dioxide emissions. Leaving an unheated conservatory open to another heated space such as a living room is equivalent to heating it.[2]

1 The window and all constructions in this example are assumed to meet the requirements of the building regulations.
2 The building regulations forbid the addition of a conservatory that is 'open-plan' to other rooms (i.e. not separated from them by walls or doors) in an existing house.

Therefore the incorporation of a conservatory in a proposed extension should be approached with great care. A 'sun room' space with an opaque, well-insulated roof (perhaps incorporating some roof windows) and partly-glazed walls will often provide bright and airy accommodation that is much more useable and comfortable than a conservatory.

Insulation

The building regulations in the UK impose 'minimum' insulation standards for domestic extensions. However, 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.

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

Exposed element	Maximum U-value (W/m^2K)
Roofs	0.13
Walls	0.25
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 $0.8W/m^2K$.

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.

Three types of insulation are commonly used in domestic extensions:

- 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 floors

New ground floors should be insulated to the Best Practice standards as shown in Table 1 above (i.e. to achieve maximum U-values of $0.20W/m^2K$). The most common types of new ground floors are:

- ground-bearing concrete slabs;
- suspended pre-cast concrete 'beam-and-block' floors;
- suspended timber floors.

Ground-bearing concrete floors can be insulated by placing insulation beneath the slab (see Figure 3) or above the slab, beneath a screed or timber floor (see Figure 4).

In the case of insulation beneath the slab, rigid insulation should be used, and if the insulation thickness exceeds about 75mm it may be necessary to include some steel reinforcement mesh in the slab itself. Depending on the size and shape of the floor, up to 100mm of high-performance insulating material (i.e. one with low thermal conductivity, not more than 0.03W/mK) may be required to meet the Best Practice standard. The perimeter of the slab should also be insulated, as shown in Figure 3.

If the insulation is placed above the slab, and the floor is finished with timber, a vapour control layer should be included beneath the timber finish, as shown in Figure 4. Again rigid insulation should be used. It is not usually practical for the thickness of the insulation to exceed about 100mm, so a high performance insulating material (i.e. one with low thermal conductivity) may be required to meet the Best Practice standard.

Figure 3: Insulating a concrete floor beneath the slab

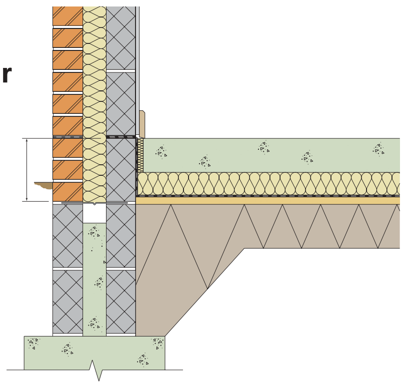
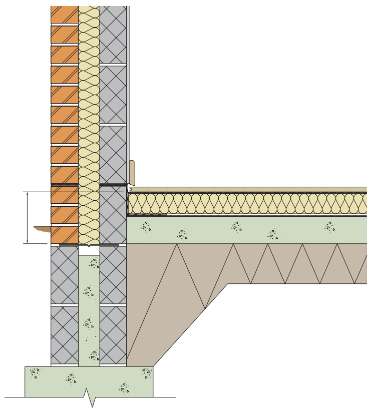


Figure 4: Insulating a concrete floor above the slab



Suspended pre-cast concrete 'beam and block' floors are usually insulated above the floor, as shown in Figure 5. Again rigid insulation should be used. The thickness of the insulation should not exceed about 100mm, so a high performance insulating material (i.e. one with low thermal conductivity) may be required to meet the Best Practice standard.

Another way of meeting the Best Practice standard is to use a proprietary type of floor in which the concrete blocks are replaced by T-shaped blocks of rigid insulation spanning between the pre-cast concrete beams. This type of construction provides good thermal performance, consistent with Best Practice, which can be further improved by also insulating above the floor, as described above.

Suspended timber floors can be insulated by placing insulation between the joists, usually to the full depth of the joists. The insulation may be supported either on timber battens fixed to the sides of the joists or on netting placed over the joists, as shown in Figure 6.

Figure 5: Insulating above a concrete 'beam and block' floor

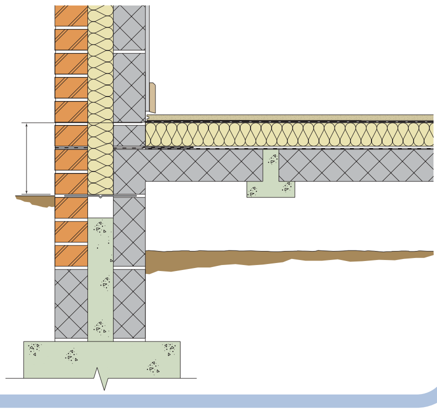
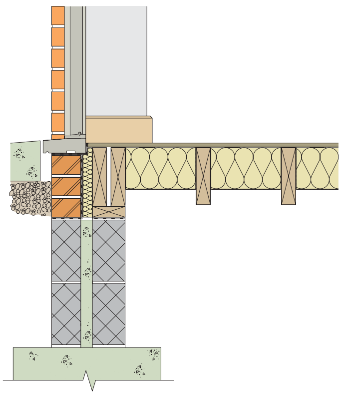


Figure 6: Insulating a suspended timber floor



Insulating exposed walls

Exposed walls should be insulated to the Best Practice standards shown in Table 1 (i.e. to achieve maximum U-values of 0.25W/m^{2}K).

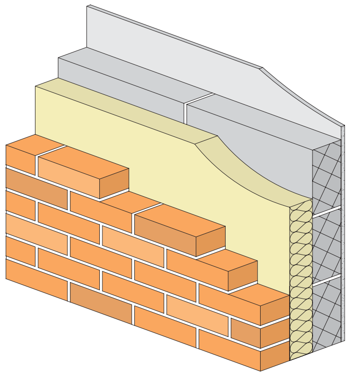
The external walls of domestic extensions are usually constructed by one of two methods:

- masonry cavity construction;
- timber-framed construction.

Masonry cavity construction consists of an outer leaf of brickwork, a 'cavity' that is fully or partially filled with insulation, an inner leaf of concrete blockwork, and a plasterboard lining (see Figure 7). The thermal performance of this type of construction varies with the thicknesses of the cavity and of the insulation, the type of blockwork used for the inner leaf, and the type of lining board. In order to meet the Best Practice standard it is necessary to:

- make the insulated cavity at least 100mm wide;
- use lightweight 'thermal' blockwork for the inner leaf; and
- use a thermal board instead of ordinary plasterboard.

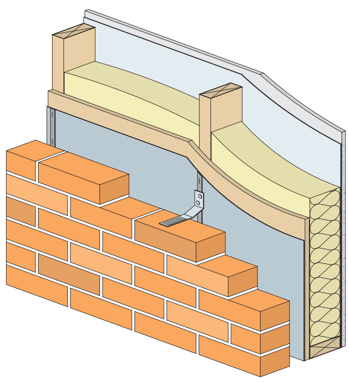
Figure 7: Insulated masonry cavity construction



Timber-framed construction usually consists of a structural timber frame with insulation placed between the framing members, lined internally with plasterboard and externally with a sheathing board and a waterproof breather membrane. The timber frame is often clad externally with a skin of brickwork, separated from the frame by a cavity (see Figure 8). Timber frames are usually either 90mm or 140mm thick. In order to meet the Best Practice standard it is necessary to:

- use at least 140mm thick framing;
- use high-performance insulation within the frame; and
- use a thermal board instead of ordinary plasterboard.

Figure 8: Insulated timber-frame construction



Insulating roofs

Roofs should be insulated to the Best Practice standards shown in Table 1 (i.e. to achieve maximum U-values of 0.13W/m^{2}K).

There are three common methods of insulating the roofs of domestic extensions:

- insulating at ceiling level (with an unheated loft above);
- insulating within the pitch of the roof (between the rafters);
- insulating a flat roof.

Where there is to be an unheated loft beneath a pitched roof, flexible insulation quilt may be placed immediately above the ceiling, between and over the ceiling joists, as shown in Figure 9. The insulation is supported by the ceiling lining (usually plasterboard or thermal board). In order to meet the Best Practice standard you must ensure the following.

- The insulation quilt should be in two layers, one between the ceiling joists, and the other across them, to prevent thermal bridging.
- The ceiling lining should be thermal board instead of ordinary plasterboard.
- The insulation material should not be compressed when it is tucked into tight corners.
- The insulation layer should be 270mm (approximately 10 inches) in thickness.

It is important to ventilate the roofspace, above the insulation, in order to reduce the risk of condensation. 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.

Where insulation is to be placed within the pitch of the roof (between the rafters) the building regulations specify that a 50mm wide ventilation gap must be maintained above the insulation (and beneath the roofing felt and tiles), in order to reduce the risk of interstitial condensation. Consequently, the thickness of any insulation placed between the rafters cannot exceed 50mm less than the depth of the rafters. Also, eaves ventilators and ridge or abutment ventilators must be installed, in order to admit ventilation air at eaves level and permit it to escape at the top of the roof.

The rafters are unlikely to be deep enough to contain sufficient insulation to meet the Best Practice standard (plus the 50mm ventilation gap). Additional insulation can be provided in two ways:

- supplement the insulation between the rafters by using a thermal board, instead of ordinary plasterboard, for the internal ceiling lining, as shown in Figure 10; or
- adopt a form of construction called a 'vapour balanced' or 'breathing' roof, as shown in Figure 11.

These options may be combined.

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.

Figure 9: Insulating a new roof at ceiling level

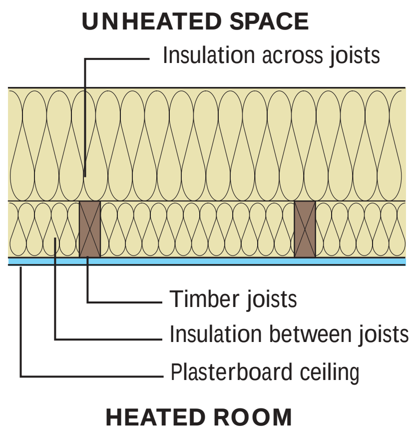


Figure 10: A ventilated pitched roof with insulation between rafters supplemented by a ceiling lining of thermal board

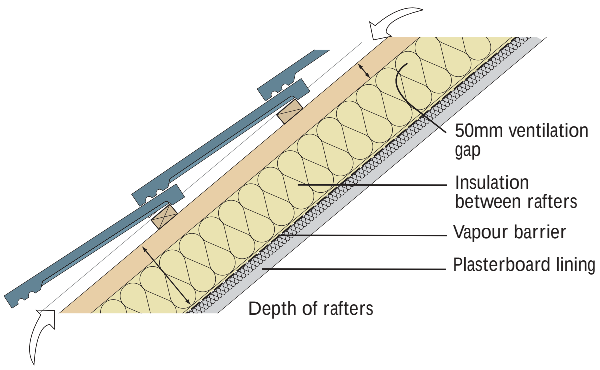
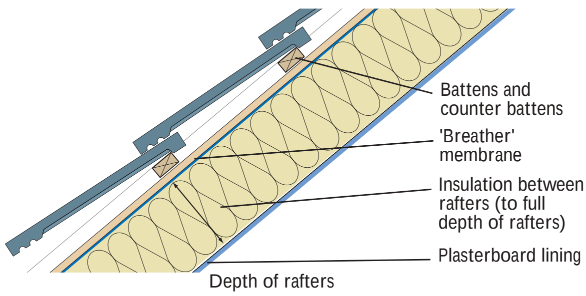
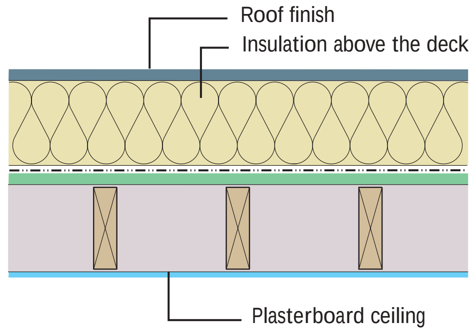


Figure 11: An unventilated insulated pitched roof with vapour balanced or 'breathing' construction, and incorporating insulation between rafters



If the roof is to be flat, a 'warm roof' construction should be used. This is the most common type of insulated flat roof construction, in which the insulation is placed above the timber structure and deck, with the waterproof external finish layer bonded directly to it, as shown in Figure 12. In order to meet the Best Practice standard it will be necessary to include a substantial thickness of rigid, high performance insulation.

Figure 12: 'Warm' insulated flat roof construction



Limiting thermal bridging and air leakage

The building regulations in the UK require that extensions must be constructed so that there are no 'thermal bridges', or gaps in the insulation layers within the various elements of the building fabric (i.e. walls, roofs and floors), at the joints between elements or around openings such as windows and doors. The construction must also include reasonable sealing measures to reduce unwanted air infiltration. In England and Wales, a way of meeting these requirements is to adopt the 'robust construction details' illustrated in *Limiting thermal bridging and air leakage: robust construction details for dwellings and similar buildings*. Similar guidance (referenced in the respective approved/technical documents) is available for Scotland and Northern Ireland.

Glazed openings

There are many combinations of frame type and glazing type that will meet the Best Practice standard shown in Table 1 (i.e. maximum U-value 1.8W/m^{2}K). Glazing types include double- and triple-glazing with different spacing, low emissivity coatings, and argon filling between the panes. Frame types include metal, PVCu and timber. Metal-frames should include thermal breaks to reduce heat loss through the frames. Examples of window types that meet the Best Practice standard 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.

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 extensions, 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 the following three 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.

Passive stack ventilation

If the extension has two storeys, or a single storey with a pitched roof, it is often 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 throughout the house. Passive stack ventilation works best when the terminals are located at or near the highest point of the roof (usually the ridge). It is especially good for ensuite bathrooms, because it is silent.

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

Heating

Boiler capacity

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

However, in some cases a well insulated extension may reduce the overall heat loss of the house (by covering up some of the original, less well insulated roof or 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 of 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 extension, 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 the following.

- 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 with 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 by the building regulations).

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 an extension, 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).

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

Room heaters

Where the house that is being extended 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 extension project. However, if this is not appropriate or affordable the extension 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 an extension 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 per cent 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 extensions) 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 most often used. Any room in which the lighting is used for more than four hours each day should be considered.
- Installing energy efficient lighting in an extension 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.

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

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.

Questions and answers

Extension shape and orientation

Q What is the best shape for my extension?

A Ideally, extensions should be compact, to reduce heat losses. Two-storeys are better than one, and complicated or elongated shapes should be avoided.

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

A 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. Aim for the area of windows to be 15 to 20 per cent of the floor area.

Q But what if my extension is north-facing?

A If you cannot avoid north-facing windows, it is appropriate to compensate for the extra heat loss by including more insulation elsewhere, e.g. in the walls or roof.

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.

Conservatories

Q Should I include a conservatory?

A Conservatories contribute significantly to heat losses, and thus to fuel use, fuel costs and carbon dioxide emissions. They are rarely comfortable in winter unless they are heated, and they tend to overheat dramatically in summer. If you wish to maximise your year-round use of the extension it is better to build a 'sun room' (i.e. a conventional extension with an opaque well insulated roof, perhaps some roof windows and well-shaded south-facing windows).

Insulation

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.

Glazed openings

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 extension 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 extension is compact, well insulated and airtight there may be little or no overall increase in overall 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 extension?

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 / GPG 194)
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 (GPG 224)

Ventilation

Energy-efficient ventilation in housing: a guide for specifiers on the requirements and options for ventilation (GPG 268)

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.

CE122

Energy Efficiency Best Practice in Housing

Energy efficient domestic extensions

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