Technical Handbook - Domestic

Table of Contents

Technical Handbook - Domestic

Energy

6.0 Introduction

6.0.1 Background

Within Scottish building regulations, improvements in energy standards have been made over many years including, in 2007, the move to a single carbon dioxide emissions based methodology for assessing carbon and energy performance in new buildings.

The Sullivan Report - in 2007, Scottish Ministers convened an expert panel to advise on the development of a low carbon building standards strategy to increase energy efficiency and reduce carbon emissions. This resulted in The Sullivan Report – 'A Low Carbon Building Standards Strategy for Scotland' [http://www.scotland.gov.uk/sullivanreport]. A key recommendation of this Report was staged improvements in energy standards in 2010 and 2013, with the aim of net zero carbon buildings (emissions for space heating, hot water, lighting and ventilation) in 2016/17, if practical.

In May 2013 Scottish Ministers reconvened the Sullivan panel with a view to revisiting some of their original recommendations, taking account of the impact of the economic downturn on the construction sector. Whilst maintaining the level of ambition, the 2013 Update report [http://www.scotland.gov.uk/Publications/2013/11/8593/0] recommended a more moderate pace of change and offered recommendations in three areas:

- eventual and staged standards – Percentage improvements recommended in 2007
- process – Extending carbon compliance beyond site - related measures, and
- costings – Recognising the value of new - build energy standards

The Climate Change (Scotland) Act 2009 http://www.legislation.gov.uk/asp/2009/12/pdfs/asp_20090012_en.pdf creates a statutory framework for delivery of greenhouse gas emissions reductions in Scotland. The Act sets an interim target of a 42% reduction in emissions (compared to 1990) by 2020, and an 80% reduction target for 2050, with annual targets set in secondary legislation. The high level measures required in each sector to meet Scotland's statutory climate change targets, for 2022 and in the long term, were set out in the Scottish Government's Climate Change Delivery Plan. This includes recommendations for the delivery of low carbon new buildings.

The construction sector has a major role to play in this respect. Emissions from the burning of fossil fuels are contributing to climate change, with energy use in buildings a significant source of such emissions. Increased energy efficiency and promotion of renewable energy are therefore an important element of Scotland's strategy to tackle climate change.

To deliver buildings that are more energy efficient and have fewer carbon dioxide emissions, a greater emphasis is needed on the overall effect that design and specification choices, construction and commissioning of new work can have on building performance.

6.0.2 Aims

The intention of Section 6 is to ensure that effective measures for the conservation of fuel and power are incorporated dwellings and buildings consisting of dwellings. In addition to limiting energy demand, by addressing the performance of the building fabric and fixed building services, a carbon dioxide emissions standard obliges a designer of new dwellings to consider building design in a holistic way.

Improvements set out within this section will result in a greater need to consider the benefits which localised or building-integrated low carbon equipment (LCE) (e.g. photovoltaics, solar water heating, combined heat and power and heat pumps) can make towards meeting standards. Although the focus is primarily on lowering carbon dioxide emissions from dwellings in use, the measures within this section are intended to reduce energy demand and continue to ensure that, for new homes and new building work, use of energy and fuel costs arising from this are both minimised.

Guidance also recognises issues relevant to requirements within Articles 3, 4, 6-9 & 11 of EU Directive 2010/31/EU [http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF] on the Energy Performance of Buildings (EPBD) and Article 13 of the EU Directive 2009/28/EC [http://europa.eu/legislation_summaries/energy/renewable_energy/en0009_en.htm] on the promotion of the use of energy from renewable sources.

The standards and guidance given in this section are intended to achieve an improvement, for new homes reducing emissions by approximately 21% compared to the previous 2010 standards (45% compared to the 2007 standards). However, nothing here prevents a domestic building from being designed and constructed to be even more energy efficient or make greater use of low carbon equipment (LCE).

6.0.3 General guidance

This section addresses the carbon dioxide emissions and energy performance of all domestic buildings (houses, flats and maisonettes) and ancillary buildings. In respect of dwellings, all parts of a building intended to form part of the dwelling should be within an insulation envelope.

This section should be read in conjunction with all the guidance to the Building (Scotland) Regulations 2004 but in particular Section 3: Environment has a close affiliation with energy efficiency, regarding:

- heating of dwellings
- ventilation of domestic buildings
- condensation
- natural lighting
- combustion air and cooling air for combustion appliances
- drying facilities, and
- storage of woody biomass.

Other than where qualified in the limitations to individual functional standards, the standards and guidance within this section apply, irrespective of the intended lifespan or the potential to relocate a building:

- to dwellings
- to ancillary and subsidiary accommodation to dwellings (some of which may be stand-alone buildings), that are to be heated (excepting heating rated at a maximum of $25W/m^2$ floor area, installed solely for the purpose of frost protection)
- to stand-alone buildings that are heated (see paragraph below), and
- to work on existing buildings (see paragraph below).

Heated stand-alone buildings - in 2007, the EU Directive 2002/91/EC [http://europa.eu/legislation_summaries/energy/energy_efficiency/l27042_en.htm] on the energy performance of buildings led to the introduction of the category of 'stand-alone building', a definition of which is available in Appendix A of the Technical Handbooks. The Directive, now recast as Directive 2010/31/EU [http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF], exempts such buildings where less than 50m^2 in floor area, from both the need to use a methodology to calculate energy performance (Standard 6.1) and also the production of an Energy Performance Certificate (Standard 6.9). The defined term includes not only detached buildings, but also thermally divided parts of a buildings with separate heating shut-down control.

Stand-alone building that are less than 50m^2 in floor area must still comply with Standards 6.2 to 6.8 (6.10 not being applicable to domestic buildings). The guidance to Standard 6.2 recommends that the insulation envelope of such a building should achieve the level of performance applicable to an extension.

Examples - common examples of stand-alone domestic buildings that could be less than 50m^2 include: a heated stair enclosure associated with a block of flats; a heated summerhouse ancillary to a dwelling; and a conservatory attached to a new or existing dwelling.

Work on existing buildings - as for other standards within Scottish building regulations, the energy standards apply to conversions and also work on existing buildings, such as extensions, conservatories, alterations and replacement work. However, in some situations, individual standards may not apply or guidance on compliance with the standards may differ for such work. The latter is usually to recognise constraints that arise when working with existing buildings.

It is advisable, in the first instance, to check the functional standard as sometimes a limitation removes certain classes of this type of work. Where not excepted by a limitation to a standard, the provisions of the standard will apply in full to the new work on the existing building, other than where proposed works are wholly categorised as a conversion, where the standard in question may be met as far as is reasonably practicable. This is identified in the introduction to the guidance supporting each standard.

6.0.4 U-values

Thermal transmittance (U-value) is a measure of how much heat will pass through one square metre of a structure when the temperature on either side differs by one degree Celsius. It is expressed in units of watts per square metre per degree of temperature difference (W/m^{2}K).

Measurements of U-values should be made in accordance with BS EN ISO 8990:1996 - 'Thermal insulation. Determination of steady-state thermal transmission properties. Calibrated and guarded hot box'. In calculation, thermal bridging may be disregarded where the difference in thermal resistance between bridging and bridged material is less than 0.1m^{2}K/W. For example, normal mortar joints need not be taken into account in calculations for brickwork, but should be taken into account for lightweight insulating blockwork.

Taking into account guidance from BRE publication BR 443:2006 'Conventions for U-value calculations', http://www.bre.co.uk/filelibrary/pdf/rpts/br_443_(2006_edition).pdf individual U-values of building elements forming the insulation envelope can be established by a number of methods, including:

a. by using insulation to a thickness derived from manufacturers' data relating to thermal conductivities (W/mK) and thermal transmittances (U-values: W/m^{2}K) certified by a notified body

b. by calculation, taking into account thermal bridging effects of, e.g. timber joists, structural and other framing and normal bedding mortar, by using the Combined Method set out in BS EN ISO 6946:2007 or CIBSE Guide Section A3, 2006 Edition

c. for floors adjacent to the ground and basements, by using the method set out in BS EN ISO 13370: 2007 or CIBSE Guide Section A3, 2006 Edition, or

d. for windows, doors and rooflights, by using BS EN ISO 10077-1: 2006 or BS EN ISO 10077-2: 2012 and, for rooflights, BS EN ISO 12567-2: 2005.

6.0.5 Thermal conductivity

The thermal conductivity (the λ-value) of a material is a measure of the rate at which that material will transmit heat and is expressed in units of watts per metre per degree of temperature difference (W/mK). Establishing the thermal conductivity of materials in a building element forming part of the insulation envelope will enable the thermal transmittance of the element to be calculated.

Measurements of thermal conductivity should be made in accordance with BS EN 12664: 2001, BS EN 12667: 2001 or BS EN 12939: 2001. There are a wide range of technical publications which give the thermal conductivity of common construction materials but, where available, preference should be given to values that are certified by a notified body. Additional guidance given in BRE publication BR 443: 2006 should also be followed.

6.0.6 Thermal transmittance through separating elements

Previously, thermal transmittance through separating walls or separating floors between 2 dwellings or between a dwelling and other heated parts of the same building (e.g. between a flat and a protected zone with space heating) was not assessed. Accommodation on both sides of the separating element was expected to be at a similar temperature when the dwellings or buildings are occupied.

This is no longer always the case. Whilst ‘no loss’ may still be assumed for solid walls, research has identified previously unanticipated heat losses from air movement in cavity separating walls. This ‘thermal bypass’ is now identified in the calculation methodology and guidance to Standard 6.1 and in guidance to Standard 6.2.

6.0.7 Buffering effects on the insulation envelope

If a dwelling or part of a building consisting of dwellings is separated from an unheated enclosed area, (for example solid waste storage accommodation, a porch, garage, protected zone or underground car park) the U-values of the walls/floors (including doors and translucent glazing) may be calculated by:

a. disregarding the buffering effects and treating the element as if it is directly exposed to the outside

b. using the relevant formulae within SAP 2012 [http://www.bre.co.uk/sap2012]

c. following the procedure in BS EN ISO 6946: 2007, or

d. following the procedure in BS EN ISO 13789: 2007.

6.0.8 Roofs that perform the function of a floor

A roof of a dwelling or building consisting of dwellings that also performs the function of a floor or similar loadbearing surface (e.g. an access deck, escape route, roof garden or car park), should be considered as a roof for the purpose of assessment within this section.

6.0.9 Conservatories and atria

A conservatory allows natural light and natural ventilation to be ‘borrowed’ through glazing and ventilators into adjacent rooms of a dwelling. In view of this, a large area of translucent material is required in the conservatory fabric to ensure that such rooms are not adversely affected. The definition of conservatory in Appendix A of the Technical Handbooks should be read in conjunction with the SAP 2012 [http://www.bre.co.uk/sap2012] document. Further guidance is given on how the standards apply to conservatories in clauses 6.1.7, 6.2.12 and 6.3.2.

In a dwelling with an atrium, it should be assumed that the atrium is to gain heat transfer from the surrounding building. The continuity of the insulation envelope occurs at the roof level (usually predominantly glazed with translucent material) and the atrium is considered to be a heated part of the dwelling.

6.0.10 Performance of fixed building services

Unless otherwise identified in text, guidance given in support of Standards 6.3 to 6.6 now refers directly to information contained within the Domestic Building Services Compliance Guide for Scotland http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs . The document replicates guidance published in support of building standards elsewhere in the UK and supports standardisation of the specification and expected performance of fixed building services throughout the UK. The Guide also provides helpful supplementary information that may assist designers in the installation and commissioning of services to delivering optimum operating efficiency.

Additional information on the use of a range of low carbon equipment (LCE), such as solar thermal systems, photovoltaic panels and heat pumps, and application within building regulations can be found within the Low Carbon Equipment Guides on the Technical Pages [http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks] of the Building Standards Division website.

6.0.11 Calculation of areas

When calculating areas for the purposes of this section and in addition to regulation 7, schedule 4, the following should be observed:

a. all areas should be measured in square metres (m^2), unless stated otherwise in this guidance

b. the area of a floor, wall or roof is to be measured between finished internal faces of the insulation envelope, including any projecting bays and in the case of a roof, in the plane of the insulation

c. floor areas are to include stairwells within the insulation envelope and also non-useable space (for example service ducts)

d. the area of an opening (e.g. window or door) should be measured internally from ingo to ingo and from head to sill or threshold.

6.0.12 Latest changes

The 2015 edition of Section 6 incorporates a number of changes whilst retaining the existing methodology introduced in 2007. The majority of these changes relate to improvement in specified performance to deliver the intended 21% aggregate reduction in carbon dioxide emissions on the 2010 standards (45% when compared to 2007 standards). A full summary of changes can be found on the Technical Handbooks [http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/pubtech] page of the Building Standards Division section of the Scottish Government website http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/pubtech.

The key changes that have been made to the standards and guidance since 1 October 2013 include:

- Standard 6.1 - SAP 2012 [http://www.bre.co.uk/sap2012] now used to calculate carbon dioxide emissions; both changes to methodology and revised carbon factors for fuels apply
- Clause 6.1.2 – comprehensive revisions of fuel package table and associated notes to deliver 21% aggregate improvement on 2010 CO_2 emissions
- Clause 6.2.1 - improved fabric backstops for new buildings
- Clause 6.2.3 – revisions to calculation of heat loss from linear thermal bridging
- Clause 6.2.9 - improved fabric backstops for extensions, option to consider improvements to existing dwelling when subject to ‘column (a)’ U-values; example provided in Annex 6B
- Standard 6.3 - standard now covers fixed secondary heating in domestic buildings
- Standards 6.3 to 6.6 - reference is now made to the Domestic Building Services Compliance Guide for Scotland for detailed guidance in support of each standard; any situations not addressed in this document are noted within the guidance to the relevant standard.
- Clause 6.8.2 – provision of ‘quick start guide’ now applies to all new dwellings.

6.0.13 Relevant legislation

EU Directive 2006/32/EC - reference should be made to UK legal requirements enforcing Article 13 of the Energy End-Use Efficiency and Energy Services Directive 2006/32/EC http://europa.eu/legislation_summaries/energy/energy_efficiency/l27057_en.htm. When building work is carried out to an existing building with a floor area of more than 1000m^2 or a new building is constructed, the energy supply companies providing services to such buildings should be notified.

EU Directive 2009/28/EC http://europa.eu/legislation_summaries/energy/renewable_energy/en0009_en.htm - promotes the use of energy from renewable sources, including promotion within national legislation. It establishes a common framework for the use of energy from renewable sources in order to limit greenhouse gas emissions, including establishment of national action plans and targets which set the share of energy from renewable sources for 2020.

6.0.14 Certification

Scottish Ministers can, under Section 7 of the Building (Scotland) Act 2003, approve schemes for the certification of design or construction for compliance with the mandatory functional standards. Such schemes are approved on the basis that the procedures adopted by the scheme will take account of the need to co-ordinate the work of various designers and specialist contractors. Individuals approved to provide certification services under the scheme are assessed to ensure that they have the qualifications, skills and experience required to certify compliance for the work covered by the scope of the scheme. Checking procedures adopted by Approved Certifiers will deliver design or installation reliability in accordance with legislation.

The Certification of Design (Section 6 – Energy) for Domestic Buildings scheme has been approved by Scottish Ministers to confirm compliance with Section 6. Details area available on the certification pages of the Building Standards Division website http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/profinfo/cert.

6.1 Carbon dioxide emissions

Mandatory Standard

Standard 6.1

Every building must be designed and constructed in such a way that:

a. **the energy performance is estimated in accordance with a methodology of calculation approved under regulation 7(a) of the Energy Performance of Buildings (Scotland) Regulations 2008, and**

b. **the energy performance of the building is capable of reducing carbon dioxide emissions.**

Limitation:

This standard does not apply to:

a. alterations and extensions to buildings, other than:

   i. alterations and extensions to stand-alone buildings having an area less than 50 square metres that would increase the area to 50 square metres or more

   ii. extensions to non-domestic buildings where the extension will have an area which is both greater than 100 square metres and greater than 25% of the area of the existing building, and

   iii. alterations to buildings involving the fit-out of the building shell which is the subject of a continuing requirement

b. conversions of buildings:

c. non-domestic buildings and buildings that are ancillary to a dwelling that are stand-alone having an area less than 50 square metres

d. buildings, which will not be heated or cooled, other than by heating provided solely for the purpose of frost protection, or

e. limited life buildings which have an intended life of less than 2 years.

6.1.0 Introduction

Standard 6.1 focuses on the reduction of carbon dioxide emissions arising from the use of heating, hot water, lighting, ventilation and cooling systems in a new dwelling. The guidance sets an overall level for maximum carbon dioxide emissions in buildings by use of a methodology which incorporates a range of parameters that influence energy use. This means that, for new dwellings, a designer is obliged to consider energy performance as a complete package rather than looking only at individual elements such as insulation or boiler efficiency - a ‘whole dwelling approach’ to energy, which offers a significant degree of design flexibility.

For the majority of new buildings, Standard 6.1 has the greatest influence on design for energy performance. Standards 6.2 to 6.6, in the main, recommend benchmark and back-stop levels to be achieved for individual elements or systems. To achieve compliance with Standard 6.1, it will be necessary to improve upon some or all of these backstop levels or incorporate additional energy efficiency measures, such as low carbon equipment (LCE).

Renewable technologies - Directive 2009/28/EC http://europa.eu/legislation_summaries/energy/renewable_energy/en0009_en.htm promotes the use of energy from renewable sources. Where the dwelling design will include use of renewable energy for heating, Article 13 of the Directive recommends, amongst other measures, consideration of use of the following:

- for biomass equipment, conversion efficiencies of 85%
- for heat pumps, those that fulfil the minimum requirements of eco-labelling established in Commission Decision 2007/742/EC (amended in 2011 & 2013) establishing the ecological criteria for the award of the Community eco-label to electrically driven, gas driven or gas absorption heat pumps, and
- for solar thermal systems, those that are subject to EU standards, including eco-labels and other technical reference systems established by the European standardisation bodies.

High-efficiency alternative systems - Article 6 of Directive 2010/31/EU http://eur-lexhttp//.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF requires that, for all new buildings, the technical, environmental and economic feasibility of high-efficiency alternative systems (such as decentralised energy supply systems using renewable energy, co-generation, district or block heating/cooling and heat pumps) are considered and taken into account in developing proposals.

This should be documented and available for verification purposes and a statement should therefore accompany the building warrant application. Further information on this process is available in the guidance note EPC 10 - 'Consideration of high-efficiency alternative systems in new buildings' [http://www.scotland.gov.uk/Resource/0042/00427425.pdf].

Conversions - in the case of conversions as specified in regulation 4, this standard does not apply.

6.1.1 Dwellings

Objective - the calculated carbon dioxide emissions (measured in kilograms per square metre of floor area per annum) for the proposed dwelling, the dwelling emissions rate (DER), should be less than or equal to the target carbon dioxide emissions for a ‘notional dwelling’, the target emissions rate (TER).

Summary of procedure - in order to establish the target carbon dioxide emissions rate (TER) for the ‘notional dwelling’ (i.e. a dwelling of the same size, shape and 'living area fraction' as the proposed dwelling), the dimensions and 'living area fraction' of the proposed dwelling and a set of standard values are input into the methodology. To calculate the emissions for the proposed dwelling (DER) a second calculation is carried out where the proposed values are input into the methodology. An alternative way of meeting Standard 6.1 which avoids the use of the calculation methodology is to design to the set of values used for the ‘notional dwelling’. This elemental approach is described in clause 6.1.6.

Standard Assessment Procedure (SAP) - The Government’s Standard Assessment Procedure for Energy Rating of Dwellings (SAP 2012 [http://www.bre.co.uk/sap2012/]) is the calculation tool which forms part of the UK National Calculation Methodology which conforms with Article 3 of Directive 2010/31/EU [http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF] on the Energy Performance of Buildings. It is approved to calculate the energy performance and the carbon dioxide emissions of an individual dwelling. At all stages, the conventions in the SAP document [http://www.bre.co.uk/sap2012/] should be read in conjunction with the specific guidance given in the clauses to this section. Designers should be familiar with the SAP methodology and their chosen software tool and be able to explain the input and calculation process in the context of the information submitted as part of the building warrant.

Non-domestic use within dwellings - some new dwellings may incorporate surgeries, consulting rooms, offices or other accommodation of a floor area not exceeding 50m² in aggregate, used by an occupant of the dwelling in a professional or business capacity. Where this occurs, the accommodation should be considered as a part of the dwelling.

6.1.2 Setting the target carbon dioxide emissions level

To set the target carbon dioxide emissions level, (i.e. the level that should not be exceeded, the TER), refer to the table to this clause. The package of measures for the fuel type for the main space heating of the proposed dwelling is selected. This package of measures is used in the methodology and no improvement factors are applied. In addition, this ‘notional dwelling' is to have the same size, shape (including floor, roof, exposed wall areas and storey heights) and 'living area fraction' as the proposed dwelling. These terms are explained in SAP 2012.

Software vendors providing BRE approved SAP 2012 software [http://www.bre.co.uk/] will incorporate a function that, with ‘Scotland’ selected, automatically generates the target CO_2 emissions level once the fuel type is selected and the ‘notional dwelling’ dimensions and 'living area fraction' have been input into the programme.

Measures to calculate target carbon dioxide emissions for the 'notional dwelling' - the measures identified in the tables below are set to deliver, on aggregate, 45% fewer carbon dioxide emissions than the 2007 standards. Whilst it is possible to construct a dwelling using one of the packages of measures (see clause 6.1.6), this table is provided solely for the purpose of setting the target emission rate (TER) for the ‘notional’ dwelling.

It is not necessary that values or elements present in these tables form part of the proposed dwelling. Designers are free to develop cost-effective and appropriate solutions which meet the TER, subject to meeting or improving upon the benchmark and backstop levels identified in guidance to Standards 6.2 to 6.6.

Table 6.1 Main space heating system fuel [1] [2] [3]

Element or system	Gas (Package 1)	LPG (Package 2)	Oil (Package 3)	Electricity (Package 4)	Biomass [4] (Package 5)
Walls	U = 0.17	U = 0.17	U = 0.17	U = 0.17	U = 0.17
Floors	U = 0.15	U = 0.15	U = 0.15	U = 0.15	U = 0.15
Roofs	U = 0.11	U = 0.11	U = 0.11	U = 0.11	U = 0.11
Openings [5]	U = 1.4	U = 1.4	U = 1.4	U = 1.4	U = 1.4

Element or system	Gas (Package 1)	LPG (Package 2)	Oil (Package 3)	Electricity (Package 4)	Biomass [4] (Package 5)
Allowance for thermal bridging [6]	0.08 x total exposed surface area	0.08 x total exposed surface area	0.08 x total exposed surface area	0.08 x total exposed surface area	0.08 x total exposed surface area
Open flues	None	One	One	None	One
Heating system, pump in heated space [7]	Gas boiler room - sealed fan flued 89% efficiency	LPG boiler room - sealed fan flued 89% efficiency	Oil boiler room - sealed fan flued 90% efficiency	Air to water heat pump 175.1% efficiency [8]	Wood pellet boiler 86% efficiency, HETAS approved
Heating system controls	Time and temperature zone control +Boiler interlock +weather compensation +delayed start	Time and temperature zone control +Boiler interlock +weather compensation +delayed start	Time and temperature zone control +Boiler interlock +weather compensation +delayed start	Time and temperature zone control	Time and temperature zone control + delayed start
Hot water (HW) system	Stored HW (from boiler) separate time control for space and water heating	Stored HW (from boiler) separate time control for space and water heating	Stored HW (from boiler) separate time control for space and water heating	Stored HW (electric immersion) separate time control for space and water heating	Stored HW (from boiler) separate time control for space and water heating
Secondary space heating	none	10% closed wood log-burning room heater [9]	10% closed wood log-burning room heater [9]	10% electric	none
Heat recovery systems	Instantaneous waste water heat recovery system, 45% efficiency	Instantaneous waste water heat recovery system, 45% efficiency	Instantaneous waste water heat recovery system, 45% efficiency	Instantaneous waste water heat recovery system, 45% efficiency	Instantaneous waste water heat recovery system, 45% efficiency
Photo-voltaics	Yes [10]	Yes [10]	Yes [10]	No	No

Table 6.2 For the 'notional dwelling' in addition all of the following applies in every fuel type

Windows, doors and rooflights	area 25% of total floor area [11]
Orientation	all glazing orientated east/west
Shading (glazing)	average overshading
Number of sheltered sides	2
Chimneys	none
Ventilation system	natural ventilation with intermittent extract fans, 4 for dwellings with floor area more than $80m^2$, 3 for smaller dwellings
Air infiltration (building fabric)	$7m^3/h.m^2$ at 50Pa
Hot water cylinder	150 litre cylinder insulated with standing heat loss of 1.89 kWh/day. Cylinder

	in heated space, cylinder temperature controlled by thermostat
Primary water heating losses (where applicable)	primary pipework fully insulated
Low energy light fittings	100% of fixed outlets
Thermal mass parameter	The value identified for the proposed building should be used
Party wall heat loss (applicable to cavity separating walls)	0.0 W/m^2K
Waste water heat recovery unit (WWHR)	Apply 2 units (shower) in dwellings with floor area more than $100m^2$, but 1 unit (shower) for smaller dwellings

Notes:

1. Where a multi-fuel appliance is proposed, assessment of both TER and DER should be based upon the fuel option with the highest carbon factor (e.g. multi-fuel stove capable of burning coal or wood is assessed as solid mineral fuel).

2. Where heat is supplied to a dwelling from more than one source, through a generation mix (e.g. community heating using both oil and biomass where heat is provided from both sources simultaneously), the primary heating element within the TER should be calculated pro rata, on the basis of the identified fuel mix. The same mix should be used in calculation of the DER, including any pro rata contribution made by solutions such as CHP. This does not apply where heat demand can be provided solely from one of the identified generating sources, in which case other identified heat sources should be considered as back-up systems and excluded from assessment.

3. Where solid mineral fuel is proposed for the main space heating system, the TER should be calculated using the values identified for oil as a fuel (package 3). This will require improvements in performance within the DER specification for compliance.

4. The biomass column should be used not only where biomass fuel is to be used but also for biogas, liquid biofuels, large scale waste combustion from boilers and waste heat from power stations.

5. U is the average U-value of all openings (windows, doors, rooflights) based on one opaque door of area 1.85m² and U=1.4, any other doors fully glazed. For windows, doors, etc. a frame factor of 0.7, light transmittance of 0.80 and solar energy transmittance of 0.63 are assumed.

6. For the purposes of setting the TER, a y-value of 0.08 is identified. Note: for DER, this element of calculation must use H_{tb} calculated from length of junctions and individual psi values (see clause 6.2.3).

7. In the case of gas, LPG and oil, the specified efficiency values for the boiler in the notional dwelling are SEDBUK(2009); distribution temperature 55°C (e.g. radiators as emitters).

8. Seasonal Performance Factor (SPF) specified for the system includes application of a distribution temperature of 55°C (e.g. radiators as emitters).

9. The closed room heater included within the fuel package table should be capable of burning wood only, not multi-fuel.

10. For purpose of calculating the benefit of the PV element in the TER reduction, region is ‘UK average’, orientation ‘SW’, pitch ‘30°’ and overshading ‘no or little’. and kWp is the smaller of:

- dwelling total floor area (in m²) x 0.01, and

- roof area limit.

The roof area limit is to ensure that the PV area does not exceed 30% of the roof area (based on 30° roof pitch and 0.12kWp per m² PV area). In the case of a flat or maisonette the roof area limit is divided by the number of storeys in the block.

11. If total exposed facade area is less than 25% of the floor area, the area of windows, doors and roofs should be taken as the area of the total exposed facade area.

6.1.3 Calculating carbon dioxide emissions for the proposed dwelling (DER)

The second calculation involves establishing the carbon dioxide emissions for the proposed dwelling (DER). To do this the values proposed for the dwelling should be used in the methodology i.e. the U-values, air infiltration, heating system, etc.

The exceptions to entering the dwelling specific values are:

a. it may be assumed that all glazing is orientated east/west

b. average overshading for glazing may be assumed if not known. 'Very little' shading should not be entered

c. 2 sheltered sides should be assumed if not known. More than 2 sheltered sides should not be entered

d. where secondary heating is proposed, if a chimney or flue is present but no appliance installed, the worst case should be assumed i.e. a decorative fuel-effect gas appliance with 20% efficiency as secondary heating. If there is no gas point, an open fire with 37% efficiency should be assumed as secondary heating burning solid mineral fuel for dwellings outwith a smokeless zone and smokeless solid mineral fuel for those that are within such a zone.

All other values can be varied, but before entering values into the methodology, reference should be made to:

- the back-stop U-values identified in guidance to Standard 6.2, and
- guidance on systems and equipment referenced in guidance to Standards 6.3 to 6.6 and the Domestic Building Services Compliance Guide for Scotland http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs .

6.1.4 Buildings with multiple dwellings

Where a building contains more than one dwelling (such as a block of flats or terrace of houses) the average carbon dioxide emissions for the proposed block or terrace (DER) may be compared to the average target CO_2 emissions (TER) for the ‘notional block or terrace'.

The average emissions for the block or terrace is the floor-area-weighted average for all the individual dwelling emissions, i.e.:

$\{(\text{emissions}_1 \times \text{floor area}_1) + (\text{emissions}_2 \times \text{floor area}_2) + (\text{emissions}_3 \times \text{floor area}_3) + \ldots)\} \div \{(\text{floor area}_1 + \text{floor area}_2 + \text{floor area}_3) + \ldots\}$

The degree of flexibility which is provided by averaging out building emissions should be used carefully. It is not intended that one or more dwellings are super-insulated (in a building consisting of dwellings) so that another may be constructed with a high percentage of glazing.

6.1.5 Common areas in buildings with multiple dwellings

Where subject to Standard 6.1, communal rooms or other areas in blocks of dwelling (which are exclusively associated with the dwellings) should be assessed either by:

a. a SBEM calculation using the methodology and guidance to Standard 6.1 for non-domestic buildings, or

b. ensuring that the glazing does not exceed 25% of the total communal floor area of the building; and the U–values, thermal bridging, air infiltration values equal or better than those given for the gas 'notional dwellings' (package 1 in the table to clause 6.1.2).

However where the common areas are less than $50m^2$ in total these rooms or areas may be treated as a stand-alone building and are not therefore subject to Standard 6.1.

6.1.6 A simplified approach

Where a dwelling is designed to one of the packages of measures in the table to clause 6.1.2, it can be considered to reduce carbon dioxide emissions to the same level as by use of the methodology, calculating and comparing DER with TER.

In using a package of measures east/west orientation, average overshading for glazing and 2 sheltered sides may be assumed for the proposed dwelling.

The simplified approach may still be used where there are minor deviations in the values input that will clearly achieve the same or a better level of emissions. For example:

- a boiler with a higher SEDBUK efficiency
- a ground source heat pump instead of an air source heat pump
- where secondary heating forms part of the TER calculation, a secondary space heating system of equal or better performance (e.g. a closed, biomass-burning room heater)
- area of openings between 20% and 25% of total floor area (windows, doors, rooflights, and roof windows)
- a declared air infiltration of $7m^3/h.m^2$ @ 50 Pa or lower
- a hot water cylinder with a declared heat loss figure (BS 1566-1: 2002) not exceeding 1.89 kWh/day

This simplified approach should not be used where there is any deviation from values in the table which will result in higher CO_2 emissions. An example of this is where the proposed dwelling has more than 4 extract fans or windows of a poorer U-value. Likewise, if some elements offer poorer performance and others offer higher performance, the simplified approach should not be used.

This approach should also not be used where there is a likelihood of high internal temperature in hot weather or where air-conditioning is proposed. Reference should be made to the guidance to Standard 6.6.

Note that an Energy Performance Certificate (EPC) will still be required, on completion of the dwelling, to meet Standard 6.9.

6.1.7 Conservatories and stand-alone buildings

Conservatories of less than $50m^2$ in area are stand-alone buildings, thermally separated from the dwelling. A dwelling to which one is attached should be assessed as if there was no conservatory proposed.

For conservatories and other ancillary stand-alone buildings of $50m^2$ or more subject to Standard 6.1, a SBEM calculation using the methodology and guidance to Standard 6.1 for non-domestic buildings should be provided, applying the standards set for domestic buildings in all other respects.

6.2 Building insulation envelope

Mandatory Standard

Standard 6.2

Every building must be designed and constructed in such a way that an insulation envelope is provided which reduces heat loss.

Limitation:

This standard does not apply to:

a. non-domestic buildings which will not be heated, other than heating provided solely for the purpose of frost protection

b. communal parts of domestic buildings which will not be heated, other than heating provided solely for the purpose of frost protection, or

c. buildings which are ancillary to dwellings, other than conservatories, which are either unheated or provided with heating which is solely for the purpose of frost protection.

6.2.0 Introduction

The levels set out in the guidance to this standard are robust back-stops and these are necessary for the following reasons:

- to help reduce energy demand, particularly in new dwellings, where use of low carbon equipment (LCE) may reduce carbon dioxide emissions but not energy consumption, and
- to ensure that a good level of fabric insulation is incorporated in building work, especially to construction elements that would be difficult or costly to upgrade in the future.

Non-repeating thermal bridging at the junctions of building elements and around openings in the building envelope form part of the calculation of energy performance in the Standard Assessment Procedure (SAP 2012 [http://www.bre.co.uk/sap2012], see clause 6.1.1). Heat loss through such junctions, if poorly designed and constructed can contribute significantly to the overall heat loss through the insulation envelope.

As fabric insulation levels improve, the rate at which heat is lost through air infiltration through the building envelope (air permeability) becomes proportionally greater. For example, in a typical 1960's house with poorly fitted windows 20% of the total heat could be lost through air infiltration. If the same building was upgraded to 2002 levels of fabric insulation but no attempt was made to improve the air permeability then the heat loss through infiltration could represent over 40% of total heat losses. When addressing infiltration, the provision of adequate, controllable ventilation is essential if both energy efficiency and good indoor air quality are to be achieved.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirements of this standard in so far as is reasonably practicable, and in no case be worse than before the conversion (regulation 12, schedule 6).

6.2.1 Maximum U-values for new buildings

Where a balanced and practical approach is taken to reducing energy demand in new dwellings, a consistent and good level of fabric insulation will limit heat loss through the building envelope. Column (a) of the table below sets out robust backstop measures. In most cases, meeting Standard 6.1 will result in even better levels of thermal insulation unless the design of a dwelling involves extensive use of building -integrated or localised low carbon equipment (LCE).

Localised areas of the same building element may be designed to give a poorer performance. These in turn will need to be compensated by the rest of the element being designed and built to a more demanding level. An example of this would be a meter box set into an external wall. These localised areas should have a U-value no worse than the figures given in column (b) of the table below. This is particularly important with regard to the control of condensation (see Section 3: Environment). Repeating thermal bridges (e.g. timber studs in a timber frame wall) should not be considered as an individual element in this respect, as these are already taken into account within a BS EN ISO 6946: 2007 U-value calculation.

For communal areas refer also to clause 6.2.13.

Table 6.3 Maximum U-values for building elements of the insulation envelope

Type of element	(a) Area-weighted average U-value (W/m^2K) for all elements of the same type	(b) Individual element U-value (W/m^2K)
Wall [1]	0.22	0.70
Floor [1]	0.18	0.70
Roof	0.15	0.35
Windows, doors and rooflights	1.6	3.3
Cavity separating wall	0.2	

Notes:

1. Excluding separating walls and separating floors between heated areas where thermal transmittance need not be assessed, beyond measures to limit heat loss arising from air movement within any cavity separating wall.

Cavity separating walls - unanticipated heat loss can arise via air movement, within a cavity separating wall, from heated areas to points outwith the insulation envelope. To limit heat loss, a separating wall cavity should have effective perimeter sealing around all exposed edges and in line with insulation layers in abutting elements which separate the dwelling from another building or from an unheated space. This allows a U-value of 0.2 to be assigned to such walls. Further reduction in heat loss can be achieved where the cavity separating wall is also fully filled with a material that limits air movement, allowing a U-value of 0.0 to be assigned.

In considering this issue, it is important that solutions also address the need to limit noise transmission (see Section 5: Noise).

6.2.2 Areas of windows, doors and rooflights

Due to the carbon emissions Standard 6.1, there is no need for guidance on minimum or maximum area for windows, doors and rooflights in new dwellings. The use of a methodology for establishing compliance with Standard 6.1 provides an equitable approach to balancing the issues of heat loss versus solar gain and natural lighting versus artificial lighting.

In certain cases where there is a desire to have a large proportion of glass it may be difficult to demonstrate compliance with Standard 6.1. In such cases, innovative solutions will need to be considered. All relevant standards and guidance should be considered, including Standard 6.6, on avoiding high internal summer temperatures.

Guidance on alterations, extensions and conversions is provided in clauses 6.2.6 to 6.2.13.

Common areas - for communal areas refer to clause 6.2.13.

6.2.3 Limiting heat loss through thermal bridging

As insulation values of new buildings improve, the need to limit heat loss through thermal bridging becomes increasingly important. Incorrect detailing at design stage or poor construction work can have a significant adverse effect on building performance.

The insulation envelope of any heated building should be designed and constructed to limit heat loss through thermal bridging. The key areas of concern are:

- repeating thermal bridging within building elements, and
- non-repeating thermal bridging at the junction between building elements and at the edges of building elements where openings in the envelope are formed.

Whilst repeating thermal bridges are taken into account in the BS EN ISO 6946: 2007 U-value calculation, a separate assessment of non-repeating thermal bridging should be carried out for new buildings which are subject to Standard 6.1. Advice and further information on assessment of the effects of thermal bridging can be found in BRE Information paper IP 1/06 – 'Assessing the effects of thermal bridging at junctions and around openings' http://www.brebookshop.com/.

The SAP calculation tool referred to in the guidance to Standard 6.1 includes an assessment of heat loss arising from non-repeating thermal bridges in new dwellings. The overall heat loss is derived from numerical modelling of individual Ψ (psi) values calculated in accordance with BS EN ISO 10211: 2007 ‘Thermal bridges in building construction - heat flows and surface temperatures - detailed calculations' [http://shop.bsigroup.com/]. Guidance on this process is given in BR 497, ‘Conventions For Calculating Linear Thermal Transmittance and Temperature Factors’ [http://www.brebookshop.com/].

To determine the value for heat loss arising from non-repeating thermal bridging (transmission heat transfer coefficient or H_{tb}) for the proposed dwelling, designers should identify the presence of junctions listed in Appendix K of SAP 2012 [http://www.bre.co.uk/sap2012] and assign Ψ values to each junction, based upon the following options:

a. input of default Ψ values for each junction listed within Appendix K of SAP 2012 [http://www.bre.co.uk/sap2012/]

b. where construction of a junction follows the 'Accredited Construction Details (Scotland) 2015' http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks or other published and substantiated construction detail sets, input of Ψ values of the relevant junction(s) from that document

c. input of Ψ values calculated by a person with suitable expertise and experience following the guidance set out in BR 497.

Note that a combination of Ψ values from these sources can be used to produce a calculated heat loss.

Further commentary on this process and use of other published documents providing sources of pre-calculated values can be found within 'Accredited Construction Details (Scotland) 2015' SAP 2012 [http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks].

6.2.4 Limiting uncontrolled air infiltration

Addressing infiltration in new dwellings can significantly reduce heat loss and result in lower carbon dioxide emissions. This can provide flexibility when applying the methodology used to meet the TER for carbon dioxide emissions (see Standard 6.1).

To limit heat loss, any heated building should be designed to limit air infiltration through the building fabric. This is done by providing a continuous barrier that resists air movement through the insulation envelope and limits external air paths into each of the following:

- the inside of the dwelling or building consisting of dwellings
- the 'warm' side of insulation layers
- spaces between the component parts of exposed building elements, where such parts contribute to the thermal performance of the element.

The infiltration rate used for the TER calculation is $7m^3/h.m^2$ @ 50 Pa (see clause 6.1.2). Whilst no backstop value is set for uncontrolled infiltration, it is recommended that buildings are designed to achieve a value of $10m^3/h.m^2$ @ 50 Pa or better to allow a balanced approach to managing building heat loss.

Where no infiltration rate is specified by the designer, a value of $15m^3/h.m^2$ @ 50 Pa will be assigned to the proposed dwelling for the purpose of the DER.

Designing and constructing a building in accordance with the principles set out in BSD's document 'Accredited Construction Details (Scotland) 2015' http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks will assist in limiting air infiltration. Due to the contribution of both detailing and workmanship, it remains difficult to achieve a specified air infiltration rate with any degree of accuracy. To ensure the dwelling will deliver the intended thermal performance without adversely affecting air quality, air tightness testing should be undertaken to verify as-built air infiltration rates (see clause 6.2.5).

Limiting air infiltration to improve energy performance should not compromise ventilation required for:

- the health of the occupants of the building (Section 3)
- the removal of moisture from building fabric (Section 3)
- the safe operation of combustion appliances (Section 3), and
- any smoke control system (Section 2).

Lower air infiltration rates, of less that $5m^3/h.m^2$ @ 50 Pa, may give rise to problems with internal air quality and condensation unless this is addressed through planned ventilation. Accordingly, where design infiltration rates are proposed below this rate, reference should be made to additional measures needed to ensure air quality under Standard 3.14, on the provision of ventilation within dwellings.

Similarly, work to improve an existing dwelling which includes measures which reduce infiltration should also consider the impact of such work on condensation risk and moisture movement within affected construction elements (see clause 6.2.10).

Common areas - in building consisting of dwellings, common areas which need particular consideration to limit air infiltration include common stair entrances and shafts which extend through most of the floors (e.g. lift and common stair enclosures).

6.2.5 Air-tightness testing

Low air infiltration rates will contribute to energy performance but should not be so low as to adversely affect the health of occupants or the building fabric. There is, therefore, a need to establish dwelling performance by test to demonstrate compliance in both these respects.

Evidence from testing of dwellings, constructed to the 2007 and 2010 Accredited Construction Details (Scotland) and of similar constructions elsewhere in the UK, indicates that air-tightness levels of 5 to $7m^3/h.m^2$ @ 50 Pa or better are readily achievable and can be exceeded unintentionally. Air-tightness testing should be carried out on new dwellings to demonstrate that air infiltration rates deliver both the stated design level under this guidance and that the proposed ventilation strategy remains appropriate (see Section 3: Environment).

Frequency of testing dwellings - testing of completed dwellings should be carried out on at least 1 in 20 dwellings or part thereof. The verifier may request that the frequency of testing be varied as considered appropriate to ‘reasonable inquiry’ and in response to previous test results within a development.

In larger developments, it is advisable to test more than one example of the same dwelling type and form, completed at different stages in the overall development, to help establish consistency in quality of construction. In smaller developments, the proportion of dwellings tested may also need to increase, dependent on the range of type and form of dwellings present, to ensure a representative sample is taken.

Normally, for a development of one dwelling, an air-tightness test should be carried out as it will not be possible to obtain comparative data on the quality of construction from similar dwellings.

Alternatively, for any single dwelling or number of dwellings, where a default design value of $15m^3/h.m^2$ @ 50 Pa is stated in demonstrating compliance under Standard 6.1, testing need not be carried out.

Testing should be in accordance with BS EN 13829: 2001 – ‘Thermal performance of buildings - determination of air permeability of buildings - fan pressurization method’ [http://shop.bsigroup.com/]. Practical advice on procedure for pressure testing is given in the ATTMA publication ‘Measuring Air Permeability of Building Envelopes' [http://www.attma.org/].

Testing should be carried out by persons who can demonstrate relevant, recognised expertise in measuring the air permeability of buildings. This should include membership of a professional organisation which accredits its members as competent to test and confirm the results of testing.

Further advice on these matters can be found in chapter 5 of the BSD publication ‘Sound and Air-tightness Testing’, 2015 Edition http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/ast2015.

6.2.6 Introducing heating to unheated buildings and conversion of unheated buildings

A building that was originally designed to be unheated has, in most instances, the greatest void to fill in terms of energy efficiency. The introduction of heating to such buildings will, if not accompanied by fabric insulation, result in disproportionate heat loss and wasteful use or fuel and power.

Where conversion of an unheated building (e.g. a barn) or part of a dwelling is to be carried out, or heating is introduced to a building that was previously designed to be unheated, the building should work to achieve the same standards to those for an extension to the insulation envelope by following the guidance in clauses 6.2.9 and 6.2.10, meeting the U-values in column (b) of the table to clause 6.2.9.

In this context, existing buildings where heating is provided solely for the purpose of frost protection (rated at a maximum of 25W per m² of floor area) shall be treated as unheated buildings.

Conversion of part of a dwelling - examples of work which involve conversion of part of a dwelling are; changing a roof space, an unheated garage or a deep solum space into an apartment:

- in the case of a roof space, this will usually involve extending the insulation envelope to include, the gables, the collars, a part of the rafters and the oxters, as well as any new or existing dormer construction. The opportunity should be taken at this time to upgrade any remaining poorly performing parts of the roof which are immediately adjacent to the conversion, for example, insulation to parts of the ceiling ties at the eaves
- in the case of an unheated garage, this will usually involve extending the insulation envelope to include, the existing floor, perimeter walls and the roof/ceiling to the new habitable part, and
- in the case of a deep solum space, this will usually involve extending the insulation envelope to include, the solum/existing floor and perimeter walls to the new habitable part.

6.2.7 Conversion of heated buildings

In the case of a building that was previously designed to be heated, the impact on energy efficiency as a result of the conversion, may be detrimental but could be negligible, or in some circumstances even an improvement.

A less demanding approach than identified in clause 6.2.6 is recommended which at the same time still ensures that some overall improvements are being made to the existing building stock.

Where an extension or conservatory is formed and/or alterations are being made to the building fabric at the same time as the conversion, the guidance given in clauses 6.2.9 to 6.2.12 should also be followed.

Where conversion of a heated building is to be carried out, the existing insulation envelope should be examined and upgraded following the table below:

Table 6.4 Maximum U-values for building elements of the insulation envelope

Type of element	(a) Area-weighted average U-value (W/m^2K) for all elements of the same type	(b) Individual element U-value (W/m^2K)
Wall [1] [2]	0.30	0.70
Floor [1] [2]	0.25	0.70
Roof [1]	0.25	0.35
Where new and replacement windows, doors and rooflights are installed [3][4]	1.6	3.3

Additional information:

1. Where upgrading work is necessary to achieve the recommended U-values, reference should be made to 'Reconstruction of elements' in clause 6.2.11 and more demanding U-values achieved, where reasonably practicable.

2. Excluding separating walls and separating floors between heated areas where thermal transmittance need not be assessed, provided measures to limit heat loss arising from air movement within a cavity separating wall are made (see clause 6.2.1).

3. The total area of windows, doors and rooflights, should not exceed 25% of the floor area of the dwelling created by conversion. Alternatively, a compensatory approach should be taken.

4. Openings with a Window/Door Energy Rating of Band C or better may also be used http://www.bfrc.org/.

6.2.8 Conversion of historic, listed or traditional buildings

With historic, listed or traditional buildings, the energy efficiency improvement measures that should be invoked by conversion can be more complex.

Whilst achieving the U-values recommended in clause 6.2.6 and 6.2.7 should remain the aim, a flexible approach to improvement should be taken, based upon investigation of the traditional construction, form and character of the building in question and the applicability of improvement methods to that construction. Provisions under other legislation (e.g. planning consent for listed buildings or those within conservation areas, where there is a need to maintain character, form or features) are also relevant. The manner in which proposed improvements may affect moisture movement or the permeability of existing construction will also require assessment to address the risk of adverse consequences.

For all buildings, it would be advisable to consider the feasibility of upgrading fabric to at least the U-values given in column (c) in clause 6.2.9 (individual element U-values). In many cases, specialist advice will be helpful in making an assessment to ensure that, in improving energy efficiency, there is no other, adverse effect to the building fabric.

Accordingly, each building will have to be dealt with on its own merits. Improvements to the fabric insulation of the building will often depend on factors such as whether or not improvement work can be carried out in a non-disruptive manner without damaging existing fabric (for example, insulating the ceiling of an accessible roof space), or whether potential solutions are compatible with the existing construction.

In certain cases, buildings are given historic or listed status because of specific features present in certain parts of the building. In these circumstances, it may be possible to make greater improvements to other less sensitive areas.

In all cases the ‘do nothing’ approach should not be considered initially. Innovative but sympathetic and practical solutions to energy efficiency, which are beyond the scope of this guidance, can often result in an alternative package of measures being developed for a building. For example, carbon dioxide emissions can be reduced without affecting building fabric through improvements to the heating system (refer to Standards 6.3 and 6.4), the lighting system (refer to Standard 6.5) or incorporation of low carbon equipment (such as a biomass boiler or heat pump). Consultation on such matters at an early stage with both the verifier and the planning officer of the relevant authority is advised.

Further guidance on issues that merit consideration and potential approaches to improvement can be found in the Historic Scotland Document ‘Guide for Practitioners 6 - Conversion of Traditional Buildings’ http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/hsg6ctb.

6.2.9 Extensions to the insulation envelope

Extension of a domestic building is not subject to Standard 6.1. In view of this, measures to limit energy demand and carbon dioxide emissions rely primarily upon the performance of the new building fabric.

As the majority of construction work for an extension will be new, there will seldom be the need to consider construction to a lesser specification as is sometimes the case for conversions and alterations. The exception to this is at the junction between existing and new, for example the need for proprietary metal ‘wall starter’ ties where the existing brickwork stops and new cavity blockwork begins. However other building standards should still be met with regard to such transitional construction elements.

Unlike a new building, an extension to an existing building will not commonly benefit from the provision of an efficient heating system or low carbon equipment (LCE). Therefore, fabric U-values should improve on the new build backstops identified in clause 6.2.1 to limit CO_2 emissions and energy demand to an equivalent level.

Accordingly, where the insulation envelope of a dwelling or a building consisting of dwellingsis extended, the new building fabric should be designed in accordance with one of two levels of elemental U-values for walls, floors, roof, windows, doors and rooflights. The maximum area weighted U-values applicable for new works to an extension is determined by the energy performance of the existing building, assessing both external wall and roof elements:

- Where both external wall and roof elements already meet or, as part of the works, will be upgraded to meet or improve upon U-values of 0.7 or 0.25 respectively, the U-Values in column (b) can be applied to the extension.

- Where a building has external wall or roof element with a U-value poorer than 0.7 or 0.25 respectively, then the more demanding U-values in column (a) apply to the extension. Alternatively, column (b) U-values may be applied where improvements to the existing building are shown to deliver a reduction in heat loss greater than or equal to the difference between the calculated overall heat loss performance of a notional extension built to column (a) U-values and one built to column (b) U-values (see compensatory approach below).

To limit heat loss through openings, the area of windows, doors, and roof lights within an extension should be limited to 25% of the floor area of the extension plus the area of any existing openings built over within the extensions. This may be exceeded where the compensatory approach (described below) is used to demonstrate that this results in no additional heat loss.

Areas of the same building element may have a poorer than average performance provided the area-weighted average U-value for all elements of the same type is maintained (e.g. by some elements having correspondingly better performance). To reduce the risk of condensation, the maximum individual element U-values should be no worse than the figures given in column (c) of the table below:

Table 6.5 Maximum U-values for building elements of the insulation envelope

Type of element	Area-weighted average U-Value (W/m^{2}K) for all elements of the same type		(c) Individual element U-Value (W/m^{2}K)
	(a) Where U-Values for wall and roof of the existing dwelling are poorer than 0.7 [1] and 0.25 respectively	(b) where parameters for column (a) do not apply	
Wall [2]	0.17	0.22	0.70
Floor [2]	0.15	0.18	0.70
Pitched roof (insulation between ceiling ties or collars)	0.11	0.15	0.35
Flat or pitched roof (insulation between rafters or roof with integral insulation)	0.13	0.18	0.35
Windows, doors, rooflights	1.4 [3]	1.6 [4]	3.3

Notes:

1. The Building Standards (Scotland) Amendment Regulations 1982, came into force on 28 March 1983, introduced thermal insulation for an exposed wall broadly equivalent to 0.7W/m^{2}K.

2. Excluding separating walls and separating floors between heated areas where thermal transmittance need not be assessed, provided measures to limit heat loss arising from air movement within a cavity separating wall are made (see clause 6.2.1).

3. Openings with a Window/Door Energy Rating of Band A may also be used http://www.bfrc.org/.

4. Openings with a Window/Door Energy Rating of Band C or better may also be used.

'Compensatory approach' using a notional extension - a compensatory approach allows U-values for the elements involved in the work to be varied provided that the resulting overall heat loss for an extension is not greater than that of a ‘notional’ extension. The ‘notional’ extension should be the same size and shape as the proposed extension, and have the area weighted average U-values from the relevant column in the table above and have an area of windows, doors and rooflights equal to 25% of the total extension floor area plus the area of built over openings.

In situations where the U-values of the existing dwelling means the extension is to be built to column (a) U-values, the compensatory approach can be extended to give applicants greater flexibility, by allowing the extension to be built to column (b) U-values providing that the further reduction in heat loss is achieved through fabric improvements to the existing dwelling.

Examples of this approach are given in annex 6B.

Whole dwelling approach - where SAP data is available for the existing dwelling, it may be practical to provide a revised SAP calculation to demonstrate compliance of a dwelling, as proposed, including extension, using the target-based methodology (DER not more than TER) set out in guidance to Standard 6.1 (carbon dioxide emissions). This option will generally only be viable where both extension and dwelling are built to the same, current edition of the standards.

6.2.10 Thermal bridging and air infiltration for existing buildings

Where works to alter, extend or convert a building, the elements involved in the building work should follow the guidance in clauses 6.2.3 and 6.2.4 on limiting heat loss from thermal bridging and air infiltration and reference should be made to the principles set out in the BSD document 'Accredited Construction Details (Scotland) 2015' http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks. Calculation of heat loss from linear thermal bridging is not necessary unless the SAP methodology is being used to demonstrate compliance.

In addition, the recommendations within Building Research Establishment (BRE) Report 262 'Thermal insulation: avoiding risks (2002 edition)' [http://www.brebookshop.com/] can be followed.

It should be noted that, unless the SAP methodology is being used to demonstrate compliance, air-tightness testing is not necessary for work to existing buildings. In such cases, a default value of $10m^3/h.m^2$ @ 50 Pa can be assumed or testing of the extension carried out as identified in clause 6.2.5.

6.2.11 Alterations to the insulation envelope

For alterations it is more than likely that the existing construction will be from a different era, in building regulation terms. In many instances each building will need to be considered on its own merits. Some of the guidance given in this clause is written in specific terms, but in certain cases (e.g. historic, listed or traditional buildings), it may be necessary to adopt alternative energy efficiency measures which relate to the amount of alteration work being undertaken.

Alterations that involve increasing the floor area and/or bringing parts of the existing building that were previously outwith the insulation envelope into the heated part of the dwelling are considered as extensions and/or conversions (regulation 4, schedule 2) and reference should be made to the relevant guidance clause for such work.

The extent to which improvement can be delivered will be affected by a range of issues, such as:

- the form and construction of the existing envelope and the scope of works

- the extent to which improvement is technically feasible without the risk of adverse consequences, and
- the impact of any other statutory requirements to which the building is subject (e.g. listing, conservation area).

Alterations to the insulation envelope of a building should be considered using the guidance in the following paragraphs.

Infill of small openings - the infill of an existing opening of approximately 4m^2 or less in the building fabric should have a U-value which matches at least that of the remainder of the surrounding element. In the case of a wall or floor however it should not be worse than 0.70W/m^{2}K, and for a roof, not worse than 0.35W/m^{2}K.

Infill of large openings - the infill of an existing opening of greater area (than approximately 4m^2) in the building fabric should have a U-value which achieves those in column (b) of the table to clause 6.2.9. Another way would be to follow the guidance in the paragraph above, but compensate for the energy efficiency deficit by improving the overall U-value of other parts of the insulation envelope.

Internal elements which become part of the insulation envelope - alteration can cause an existing internal element of a building to become part of the insulation envelope. This will most likely occur where a part of a building is permanently removed as a phase of the alteration work. Where this occurs, that part of the building (including any infill construction) should have U-values which achieve those in column (b) of the table to clause 6.2.9. Another approach would be to follow the guidance given in the previous paragraph, but compensate for the energy efficiency deficit by improving the overall U-value of other parts of the insulation envelope.

However, where this occurs at a boundary, no upgrading need be carried out if the element is a wall that is exclusively the property of the adjoining building.

Windows, doors and rooflights - where windows, doors and rooflights are being created or replaced, they should achieve the U-value recommended in column (b) of the table to clause 6.2.9. A compensating approach may be used and an example of this is given in annex 6A.

Where the work relates only to 1 or 2 replacement windows or doors, to allow matching windows or doors be installed, the frame may be disregarded for assessment purposes, provided that the centre pane U-value for each glazed unit is 1.2W/m^{2}K or less. For secondary glazing, an existing window, after alteration should achieve a U-value of about 3.5W/m^{2}K.

Areas of windows, doors and rooflights - where additional windows, doors and rooflights are being created, the total area (including existing) of these elements should not exceed 25% of the total dwelling floor area. In the case of a heated communal room or other area (exclusively associated with the dwellings), it should not exceed 25% of the total floor area of these rooms/areas.

Reconstruction of elements - where the build-up of an element forming part of the insulation envelope is to be altered or dismantled and rebuilt, the opportunity should be taken to improve the level of thermal insulation.

Column (b) of the table to clause 6.2.9 gives benchmark U-values and in many cases these can be achieved without technical risk. within the constraints of the existing construction. It is recognised however certain constructions are easier to upgrade than others and these values should be met as far as is reasonably practicable.

A building that was in a ruinous state should, after renovation, be able to achieve almost the level expected of new construction. It may not however be reasonably practicable for a dwelling, which is in a habitable condition, to have its internal space significantly reduced in area or height in order to accommodate insulation; or for excessive enabling alterations to be caused by the fitting of external thermal insulation, unless the owner/occupier of the dwelling intends that these changes are to be made. Other building standards and the impact that they will have when upgrading thermal insulation should be taken into account.

In the majority of cases however, after an alteration of this nature to the insulation envelope, a roof should be able to achieve at least an average U-value of 0.35 and in the case of a wall or floor, 0.70W/m^{2}K.

For older buildings of traditional construction, further guidance to assist in this assessment can be found in the Historic Scotland Document ‘Guide for Practitioners 6 - Conversion of Traditional Buildings’ http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/hsg6ctb.

Thermal bridging and air infiltration - when alterations are carried out, attention should still be paid to limiting thermal bridging at junctions and around windows, doors and rooflights and limiting air infiltration (clause 6.2.10). However, only the work that forms the alteration and the impact of that work on the existing building need be considered.

6.2.12 Conservatories

Conservatories are a common addition to many dwellings. Traditionally used as an ancillary space, occupied for part of the year, conservatories are now often used year-round leading to an increased heating demand. Accordingly, such buildings should, like other heated stand-alone buildings, be constructed to limit energy demand and reduce CO_2 emissions.

Some smaller conservatories can be exempt from both building warrant and building standards (see Section 0). Conservatories of 50m^2 or more are subject to Standard 6.1 of the non-domestic guidance.

Thermal division - a conservatory should be thermally divided from a dwelling, being outwith the insulation envelope of the dwelling. The dividing elements (e.g. wall, door, window) should have U–values equal or better than the corresponding exposed elements in the rest of the dwelling.

U-values - although conservatories are attached to dwellings, they are stand-alone buildings. Where not exempt, a conservatory (heated or unheated) should be built to the same maximum U-values as any other new work, as listed in columns (b) and (c) of the table in clause 6.2.9. The exception is that glazing and framing elements forming the walls or roof of a conservatory are unlimited in area and should have a maximum area-weighted average U-value of 1.8W/m^{2}K and a maximum individual element U-value of 3.3W/m^{2}K.

U-values of glazing elements forming the roof are usually quoted in the vertical plane and should therefore be adjusted allowing for the angle of the roof. Further guidance and U-value adjustments can be found in BR 443: 2006 ‘Conventions for U-value calculations’ [http://www.bre.co.uk/filelibrary/pdf/rpts/br_443_(2006_edition).pdf].

Varying U-values - 'Compensating U-values for windows, doors and rooflights’ - individual U-values for the glazed and framing elements may exceed 1.8W/m^{2}K provided that the average U-value for all the glazed and framing elements is no greater than 1.8W/m^{2}K. An example of this approach is given in annex 6A.

Thermal bridging and air infiltration - in order to limit air infiltration and thermal bridging at junctions and around windows, doors and rooflights, guidance in clause 6.2.10 should be followed.

If using the Building Standards Division document: 'Conservatories' http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/

techhandbooks/techconserv2nd, these issues will be considered to have been taken into account. Draught stripping for existing windows and doors which are part of the thermal division between the conservatory and the dwelling should be of a similar standard as the exposed windows and doors elsewhere in the dwelling.

6.2.13 Stand-alone buildings

Thermal division of a stand-alone building from the remainder of a dwelling or domestic building is explained in clause 6.2.12.

For heated stand-alone buildings of less than 50m^2, the fabric values identified in columns (b) and (c) of the table to clause 6.2.9 and clause 6.2.10 should be followed. U-value recommendations should be met, though it should be noted that the area of glazing is not limited. This allows, for example, a dwelling to be extended to create a highly-glazed stand-alone building such as a sunroom, with glazing in excess of the limits identified in clause 6.2.9.

Stand-alone buildings of 50m^2 or more are subject to Standard 6.1. Reference should be made to clause 6.1.7 and use of the non-domestic calculation methodology to assess carbon dioxide emissions.

Common areas - where the total area of a communal room or other heated accommodation associated with a block of dwellings is less than 50m^2, these rooms or accommodation should also be treated as a stand-alone building. Elements (including dividing elements) should have U-values equal to or better than those chosen for the rest of the building, as determined in conjunction with the methodology in Standard 6.1. As part of a new building, the area of windows, doors, rooflights and roof windows in these rooms or accommodation should be limited to 25% of the total floor area of these common areas.

6.3 Heating system

Mandatory Standard

Standard 6.3

Every building must be designed and constructed in such a way that the heating and hot water service systems installed are energy efficient and are capable of being controlled to achieve optimum energy efficiency.

Limitation:

This standard does not apply to:

a. buildings which do not use fuel or power for controlling the temperature of the internal environment, or

b. heating provided solely for the purpose of frost protection.

6.3.0 Introduction

In the design of domestic buildings, the energy efficiency of the heating plant is an important part of the package of measures which contributes to the overall dwelling carbon dioxide emissions. In practice the backstop levels given in this guidance for appliance efficiencies and controls will normally be exceeded to achieve compliance with Standard

6.1 for new buildings. The notional dwelling standard specifications already indicate this (refer to clause 6.1.4).

This guidance refers to main heating systems for dwellings. Both the primary heating and secondary heating systems are taken account of in SAP 2012 [http://www.bre.co.uk/sap2012].

When the guidance in Section 3 on heating requirements for dwellings is considered along with Standard 6.1, central heating (rather than using several individual appliances as primary heating) will usually be the most practical way to satisfy the standards.

Renewable technologies - Directive 2009/28/EC promotes the use of energy from renewable sources. Where the dwelling design will include use of renewable energy for heating, Article 13 of the Directive recommends, amongst other measures, consideration of use of the following:

- for biomass equipment, conversion efficiencies of 85%
- for heat pumps, those that fulfil the minimum requirements of eco-labelling established in Commission Decision 2007/742/EC (amended in 2011 & 2013) establishing the ecological criteria for the award of the Community eco-label to electrically driven, gas driven or gas absorption heat pumps, and
- for solar thermal systems, those that are subject to EU standards, including eco-labels and other technical reference systems established by the European standardisation bodies.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirements of this standard in so far as is reasonably practicable, and in no case be worse than before the conversion (regulation 12, schedule 6).

6.3.1 Performance of fixed heating systems in new and existing buildings

The minimum performance of, space heating and hot water systems, heating appliances and controls is set out in the Domestic Building Services Compliance Guide for Scotland http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs.

The document replicates guidance published in support of building standards elsewhere in the UK and supports standardisation of the specification and expected performance of fixed building services throughout the UK. The guidance applies to new systems and replacement, in whole or in part, of existing systems. It also addresses improvement work to existing systems as a consequence of replacing components.

Clause 6.3.2 provides information on situations not addressed in that document.

Historic, listed or traditional buildings - in many cases heating system improvements to historic, listed or traditional buildings will be more feasible than other energy efficiency measures such as improving wall insulation. Where this is the case, systems which go beyond these minimum backstop levels may help offset the deficiency in other areas of energy efficiency and carbon dioxide emissions.

6.3.2 Conservatories

As a conservatory which is heated will be inefficient in energy terms, the general guidance to occupiers is that they should be heated as little as possible. In view of the fact that heating is often desired particularly at the start and end of the heating season, any conservatory with heating installed should have controls that regulate it from the rest of the dwelling e.g. a thermostatic radiator valve (TRV) to each radiator.

6.4 Insulation of pipes, ducts and vessels

Mandatory Standard

Standard 6.4

Every building must be designed and constructed in such a way that temperature loss from heated pipes, ducts and vessels, and temperature gain to cooled pipes and ducts, is resisted.

Limitation:

This standard does not apply to:

a. buildings which do not use fuel or power for heating or cooling either the internal environment or water services

b. buildings, or parts of a building, which will not be heated, other than heating provided solely for the purpose of frost protection, or

c. pipes, ducts or vessels that form part of an isolated industrial or commercial process.

6.4.0 Introduction

Thermal insulation to heating pipes and ducts and hot water storage vessels will improve energy efficiency by preventing:

- uncontrolled heat loss or heat gains from such equipment, and
- an uncontrolled rise in the temperature of the parts of the building where such equipment is situated.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirements of this standard as is reasonably practicable, and in no case be worse than before the conversion (regulation 12, schedule 6).

6.4.1 Insulation of pipes, ducts and vessels in new and existing buildings

Guidance on the insulation of pipes, ducts and vessels is set out, in the context of the systems of which they form a part, in the Domestic Building Services Compliance Guide for Scotland http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs.

The document replicates guidance published in support of building standards elsewhere in the UK and supports standardisation of the specification and expected performance of fixed building services throughout the UK. The guidance applies to new systems and replacement, in whole or in part, of existing systems. It also addresses improvement work to existing systems as a consequence of replacing components.

Clause 6.4.2 provides information on situations not addressed in that document.

6.4.2 Work on existing buildings

Where a new boiler or hot water storage vessel is installed, or where existing systems are extended, new or existing pipes, ducts and vessels that are accessible or exposed as part of the work should be insulated as for new systems. Replacement hot water storage vessels should be insulated as for new systems.

It is recognised that complete insulation will sometimes not be possible, where such services pass through or around structural building components, floor joists, for example, or where existing systems are wholly or partially retained as part of conversion works. In such cases, insulation should be fitted as for new systems as far as is reasonably practicable.

6.5 Artificial and display lighting

Mandatory Standard

Standard 6.5

Every building must be designed and constructed in such a way that the artificial or display lighting installed is energy efficient and is capable of being controlled to achieve optimum energy efficiency.

Limitation:

This standard does not apply to:

a. process and emergency lighting components in a building, or

b. alterations in dwellings or a building ancillary to a dwelling.

6.5.0 Introduction

Artificial lighting can account for a substantial proportion of the electricity used within a building. Appropriate lighting design (including use of natural daylight) can reduce carbon dioxide emissions and running costs, and can also reduce internal heat gains.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirements of this standard in so far as is reasonably practicable, and in no case be worse than before the conversion (regulation 12, schedule 6).

6.5.1 Fixed lighting

Guidance on the efficiency of fixed internal and external lighting is given in the Domestic Building Services Compliance Guide for Scotland [http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs].

The document replicates guidance published in support of building standards elsewhere in the UK and supports standardisation of the specification and expected performance of fixed building services throughout the UK. The guidance applies to new systems and replacement, in whole or in part, of existing systems. It also addresses improvement work to existing systems as a consequence of replacing components.

Common Areas of domestic buildings - controls to enable the safe use of lighting in common areas such as corridors, stairs and other circulation areas, are identified in guidance to Section 4.

6.6 Mechanical ventilation and air conditioning

Mandatory Standard

Standard 6.6

Every building must be designed and constructed in such a way that:

a. **the form and fabric of the building minimises the use of mechanical ventilating or cooling systems for cooling purposes, and**

b. **ventilating and cooling systems installed are energy efficient and are capable of being controlled to achieve optimum energy efficiency.**

Limitation:

This standard does not apply to buildings which do not use fuel or power for ventilating or cooling the internal environment.

6.6.0 Introduction

It is not desirable that dwellings or buildings consisting of dwellings have air-conditioning systems or use mechanical ventilation systems for cooling purposes, as this leads to increased energy use and higher carbon dioxide emissions. In view of this, guidance is intended to promote designs that avoid the need for such systems in dwellings. However where such systems are installed, which should generally only be a consideration when working with existing buildings, a performance specification to limit energy use is set out.

With the drive to reduce carbon dioxide emissions and limit energy demand in buildings, the need arises to consider efficient use of mechanical systems, including ventilation. Accordingly, guidance is now offered on power consumption and controls of such systems and on the efficiency of systems that incorporate heat recovery.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirement of this standard in so far as is reasonably practicable, and in no case be worse than before the conversion (regulation 12, schedule 6).

6.6.1 Form and fabric of the building

Reduce overheating - in order to minimise any need for mechanical ventilation for cooling or air-conditioning due to high internal temperatures in hot weather the following issues should be considered with regard to the form and the fabric of the dwelling:

a. proportion of translucent glazing taking into account the need for daylighting and artificial lighting (Section 3 Environment and Standard 6.5)

b. orientation of translucently glazed areas

c. solar shading or other solar control measures where areas of the external building fabric are susceptible to solar gain

d. natural ventilation (including night cooling), and

e. thermal mass.

Further information is available in the Energy Saving Trust publication CE129 - 'Reducing Overheating - A Designer's Guide' [http://www.energysavingtrust.org.uk/].

Poor cross ventilation/high proportion of translucent glazing - where a dwelling has little or no cross ventilation (e.g. flats with all external windows/rooflights on one southerly elevation which is orientated between due east and due west) or a high proportion of translucent glazing:

a. the dwelling should be designed to avoid high internal temperature (refer to advice above), and

b. it should be shown by calculation that the ‘likelihood of high internal temperature in hot weather’ in the dwelling is ‘not significant, slight or medium’. The recommended method to assess this is Appendix P to SAP 2012 [http://www.bre.co.uk/sap2012/]. The intention is to avoid the situation where a dwelling occupier installs mechanical cooling or air-conditioning at a later date.

Cooling system - where a mechanical cooling system is to be considered for a dwelling:

a. the dwelling should first be designed to avoid any need for a cooling system (refer to advice above), and

b. then the ‘likelihood of high internal temperature in hot weather’ should be assessed using Appendix P of SAP 2012.

If the 'likelihood of high internal temperature' is 'not significant, slight or medium' an air-conditioning system should not be installed.

6.6.2 Efficiency of mechanical ventilation and air conditioning systems in new and existing buildings

Guidance on the efficiency of mechanical ventilation and air conditioning systems is given in the Domestic Building Services Compliance Guide for Scotland http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs.

The document replicates guidance published in support of building standards elsewhere in the UK and supports standardisation of the specification and expected performance of fixed building services throughout the UK. The guidance applies to new systems and replacement, in whole or in part, of existing systems. It also addresses improvement work to existing systems as a consequence of replacing components.

Clause 6.6.3 provides information on situations not addressed in that document.

6.6.3 Design and installation of Ductwork

The design and installation of ductwork design can have a significant effect on the effectiveness of a ventilation system. Further guidance on basic good practice in installation and commissioning of ventilation systems can be found in the BSD ‘Domestic

Ventilation' Guide [http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks], published on the Building Standards Division website.

Reference should be made to Section 3: Environment for the provision of ventilation to buildings.

6.7 Commissioning building services

Mandatory Standard

Standard 6.7

Every building must be designed and constructed in such a way that energy supply systems and building services which use fuel or power for heating, lighting, ventilating and cooling the internal environment and heating the water, are commissioned to achieve optimum energy efficiency.

Limitation:

This standard does not apply to:

a. major power plants serving the National Grid

b. the process and emergency lighting components of a building

c. heating provided solely for the purpose of frost protection, or

d. energy supply systems used solely for industrial and commercial processes, leisure use and emergency use within a building.

6.7.0 Introduction

Commissioning in terms of this section means, raising the building services systems covered by this guidance from a level of static completion to full working order and achieving the levels of energy efficiency that the component manufacturers expect from their product(s). Commissioning however, should also be carried out with a view to enabling the safe operation of the installation.

Although there is no requirement within Section 6 for minimum efficiency levels of either, building-integrated or localised energy supply systems (e.g. diesel generators, micro wind turbines or photovoltaic arrays), there is a need for commissioning to be carried out to enable efficient use, unless they are exempt under schedule 1, regulation 3. Power plants which serve a number of buildings (e.g. housing estates) and only export surplus electricity to the National Grid will also need to be commissioned, unless exempt in terms of schedule 1, regulation 3.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirement of this standard (regulation 12, schedule 6).

6.7.1 Inspection and commissioning

All heating, hot water service, ventilating or cooling systems and any decentralised equipment for power generation in a dwelling or other area of a building consisting of dwellings should be inspected and commissioned in accordance with manufacturers' instructions to enable optimum energy efficiency.

Guidance and supplementary information to assist the commissioning of installed building services is given in the Domestic Building Services Compliance Guide for Scotland http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/dbscgs. The document is intended to support standardisation of the specification and expected performance of fixed building services throughout the UK. The guidance applies to new and replacement systems and components.

6.8 Written information

Mandatory Standard

Standard 6.8

The occupiers of a building must be provided with written information by the owner:

a. **on the operation and maintenance of the building services and energy supply systems, and**

b. **where any air-conditioning system in the building is subject to regulation 17, stating a time-based interval for inspection of the system.**

Limitation:

This standard does not apply to:

a. major power plants serving the National Grid

b. buildings which do not use fuel or power for heating, lighting, ventilating and cooling the internal environment and heating the water supply services

c. the process and emergency lighting components of a building

d. heating provided solely for the purpose of frost protection

e. lighting systems in a domestic building, or

f. energy supply systems used solely for industrial and commercial processes, leisure use and emergency use within a building.

6.8.0 Introduction

Correct use and maintenance of building services equipment is essential if the benefits of enhanced energy efficiency are to be realised from such equipment. The intention of this standard is to make the information that will help achieve this available to the occupier of the building.

Although there is no requirement within Section 6 for minimum efficiency levels of either, building-integrated or localised energy supply systems (e.g. diesel generators, micro wind turbines or photovoltaic arrays), there is a need for user and maintenance instructions to enable efficient use, unless they are exempt under schedule 1, regulation 3.

Power plants which serve a number of buildings (e.g. housing estates) and only export surplus electricity to the National Grid will also need to have user and maintenance instructions, unless exempt in terms of schedule 1, regulation 3.

Conversions - in the case of conversions, as specified in regulation 4, the building as converted shall meet the requirement of this standard (regulation 12, schedule 6).

6.8.1 Written information

Written information should be made available for the use of the occupier on the operation and maintenance of the heating, ventilation, cooling and hot water service system, any additional low carbon equipment installations and any decentralised equipment for power generation to encourage optimum energy efficiency. If an air conditioning system is installed in a dwelling the guidance to regulation 17 should be followed.

6.8.2 Quick Start Guide

In addition to comprehensive information provided under clause 6.8.1, a quick start guide, identifying all installed building services, the location of controls and identifying how systems should be used for optimum efficiency should be provided for each new dwelling. Further information and an example of such a guide can be found within Section 7 (Sustainability) – refer to Annex 7B [http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/techhandbooks/th2015dom7].

6.8.3 Work on existing buildings

Where alterations are carried out to building services on a piecemeal basis, the alterations may not result in optimum energy efficiency being attained for the whole system. In this case a list of recommendations which would improve the overall energy efficiency of the system should be provided.

6.9 Energy performance certificates

Mandatory Standard

Standard 6.9

Every building must be designed and constructed in such a way that:

a. **an energy performance certificate for the building is affixed to the building, and** *

c. **the energy performance certificate is displayed in a prominent place within the building**.

Limitation:

a. This standard does not apply to:

   i. buildings which do not use fuel or power for controlling the temperature of the internal environment

   ii. non-domestic buildings and buildings that are ancillary to a dwelling that are stand alone having an area less than 50 square metres

   iii. conversions, alterations and extensions to buildings other than -

      (aa) alterations and extensions to stand-alone buildings having an area less than 50 square metres that would increase the area to 50 square metres or more, and

      (bb) alterations to buildings involving the fit-out of the building shell which is the subject of a continuing requirement, or

b. Standard 6.9(c) only applies to buildings:

   i. with a floor area of more than 250 square metres

   ii. into which members of the public have an express or implied licence to enter, and

   iii. which are visited by members of the public on at least a weekly basis

* Standard 6.9(b) removed by the Building (Scotland) Amendment Regulations 2008 (http://www.legislation.gov.uk/ssi/2008/310/contents/made).

6.9.0 Introduction

Article 12 of Directive 2010/31/EU http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF on the Energy Performance of Buildings requires that, when buildings or building units are constructed, sold or rented out, an energy performance certificate (EPC) http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/enerperfor or a copy thereof is shown to the prospective new tenant or buyer and handed over to the buyer or new tenant. Standard 6.9 ensures the continued presence of such information for buyers and tenants by also making EPCs fixtures within buildings.

EPCs must be produced in an independent manner and be carried out by qualified/accredited experts. With the exception of EPCs produced in relation to a building warrant applied for before 9 January 2013, EPCs must be produced by members of an Approved Organisation. Scottish Ministers have appointed a number of Approved Organisations (AO) to deliver certification services, with each AO following an Operating Framework which is published on the Building Standards Division website. Information on this framework and Approved Organisations can be found at http://www.scotland.gov.uk/epc.

Scottish Ministers have directed local authorities to apply Standard 6.9 (a) to existing buildings using Section 25 (2) of the Building (Scotland) Act 2003. The direction limits the description of the buildings to which this standard applies to those that are being sold or rented out, in support of duties imposed by The Energy Performance of Buildings (Scotland) Regulations 2008 http://www.legislation.gov.uk/ssi/2008/309/contents/made.

Definitions in application of this standard 'energy performance certificate' has the same meaning as given in The Energy Performance of Buildings (Scotland) Regulations 2008 http://www.legislation.gov.uk/ssi/2008/309/contents/made.

Guidance leaflets are available on the BSD website (http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/pubepc) explaining the action that building owners need to take in order to comply.

Conversions - in the case of conversions, as specified in regulation 4 Standard 6.9 does not apply.

6.9.1 Calculating the carbon dioxide emissions for a certificate

The EU Directive allows energy performance to be reflected in one or more numeric indicators. For this to be done in a transparent manner that is meaningful in terms of Scottish building regulations, the measure to be used is carbon dioxide.

Simplified approach - the certification must be carried out using the Directive compliant methodology and the calculation tool which was used to assess compliance with Standard 6.1. In most cases SAP 2012 [http://www.bre.co.uk/sap2012] will have been used for the new dwelling. However if the simplified approach referred to in clause 6.1.6 has been adopted for the new dwelling, the construction specification for the building, as constructed, will require to be input in full to enable generation of the EPC.

Use of actual values - for the purpose of establishing a rating for the energy performance certificate for a new dwelling, the values and specifications used to obtain building warrant (as varied by any subsequent amendments to warrant) should be adopted. Where a domestic building contains multiple dwellings, a rating is required for each individual dwelling. For certification purposes the rating is calculated with the percentage of low energy lighting and the type of heating as installed. Note, there will be no need to assume 10% electric secondary heating if secondary heating is not present.

Non-domestic use within dwellings - accommodation up to $50m^2$ used by an occupant of a dwelling in their professional or business capacity should be considered as a part of the dwelling.

6.9.2 Information to be provided for buildings

The energy performance certificate must display the following information:

- the postal address of the building for which the certificate is issued
- a unique reference number (other than for an EPC produced in support of a building warrant applied for before 9 January 2013)
- the date of the assessment

- the date of the certificate
- the dwelling type
- the type of assessment used for certification
- the conditioned floor area of the building
- the main heating and fuel type
- a primary energy indicator
- the current and potential energy efficiency rating expressed on seven band scale representing the following bands of running costs; A, B, C, D, E, F and G, where A = excellent and G = very poor
- the current and potential environmental impact rating expressed on a seven band scale representing the following bands of carbon dioxide emissions; A, B, C, D, E, F and G, where A = excellent and G = very poor
- a list of the top applicable recommendations for cost-effective improvements
- a statement indicating that more detailed information on the recommendations made in the EPC is contained in the recommendations report, and
- a statement to the effect that the EPC must be affixed to the building and not to be removed unless it is replaced with an updated version.

The recommendations report, which must accompany the EPC, but which does not have to be affixed to the building, includes the following additional information:

- a summary of the energy performance related features of the dwelling
- estimated energy costs (based upon standard use patterns), and
- a list of all improvements identified for the dwelling and further information on each measure.

An example of the EPC and recommendations report is available on the Building Standards Division website.

Cost-effective improvement - there are cost-effective, low-cost, energy efficiency improvements that can be made to most dwellings (when no other work is proposed) such as upgrade insulation in an accessible roof space or fit low energy lamps throughout the dwelling. Measures presented on the certificate and recommendations report must meet Scottish building regulations, relevant to the individual dwelling and should be technically feasible.

Additional advice - a piece of advice that is worthwhile including is that a conservatory (where one is installed) is only an energy efficiency benefit to the dwelling if it remains unheated and is not mechanically cooled.

The recommendations report may give additional advice on protected energy costs and improvements that are cost-effective only when additional work is being carried out e.g. providing insulation when replacing flat roof coverings.

Some experts providing certificates may wish to add extra value and give additional advice to their clients. All of this is welcome, but in every case, such information should be clearly explained in the addendum section of the recommendations report and be accompanied by advice on relevant warrants and building regulations. Sources of further energy saving advice and funding options are also noted in the recommendations report.

6.9.3 Location of an energy performance certificate

The energy performance certificate should be indelibly marked and located in a position that is readily accessible, protected from weather and not easily obscured. A suitable location could be in a cupboard containing the gas or electricity meter or the water supply stopcock.

6.9.4 Conservatories and other stand-alone buildings

For conservatories and for other ancillary stand-alone buildings of less than $50m^2$ floor area, an energy performance certificate need not be provided. For those buildings of a floor area of $50m^2$ or more, the guidance in the Non-domestic Technical Handbook should be followed and an additional certificate supplementing the one for the dwelling should be provided.

6.10 Metering

Mandatory Standard

Standard 6.10

Every building must be designed and constructed in such a way that each building or part of a building designed for different occupation is fitted with fuel and power meters.

Limitation:

This standard does not apply to:

a. domestic buildings

b. district or block heating systems where each part of the building designed for different occupation is fitted with heat meters, or

c. heating fired by solid fuel or biomass.

6.10.0 Introduction

This standard does not apply to domestic buildings as fuel providers e.g. gas companies, provide meters to dwellings to enable correct charging for fuel used by the customer.

Annex 6.A Compensating U-values for windows, doors and rooflights

6.A.0 Introduction

This annex gives guidance on how to calculate the average U-values for windows, doors, and rooflights and supports the guidance to Standards 6.1 and 6.2. It may be used with the elemental methods provided and, in particular:

- the simplified approach in the guidance to Standard 6.1, where it is not possible to input the individual U-values for all the windows, doors and rooflights for the proposed new dwelling into the methodology (usually SAP 2012), and
- for work on existing domestic buildings, namely, conversions, extensions, replacements, alterations, and conservatories (clauses 6.2.6 to 6.2.12).

Individual windows, doors or rooflights may exceed the relevant area-weighted average U-values identified in guidance provided that the average U-value calculated for all the windows, doors and rooflights is no greater than that relevant U-value.

The example which follows below illustrates how this trade-off can be calculated.

6.A.1 Example of trade-off between windows, doors and rooflights

A semi-detached house has a total window area of 17.8m^2 (including frames) and a total door area of 3.8m^2. It is proposed to use 2 external quality timber finished fire doors with a U-value of 1.9W/m^{2}K.

In order to meet Standards 6.1 and 6.2, the additional heat loss due to the use of the poorer external doors should be compensated for by more demanding U-values in the windows and/or rooflights so that the average overall U-value of such elements does not exceed 1.8W/m^{2}K (see table to clause 6.2.1).

Specifying windows and rooflights with a U-value of 1.5W/m^{2}K can achieve this requirement, as shown by the following table and subsequent calculation:

Table 6.6 Average U-value calculation

Element	Area (m^2)		U-value (Wm^{2}K)		Rate of heat loss (W/K)
Windows	16.9	x	1.5 [1]	=	25.35
Doors	3.8	x	1.9	=	7.22
Rooflights	0.9	x	1.8 [1]	=	1.62
Total	21.6				**34.19**

Notes:

1. Note that although the windows and rooflights have the same U-value, for the purpose of calculation the rooflight value is 0.3W/m^{2}K poorer due to inclination from the vertical plane (see BR 443 - 'Conventions for U-value Calculations' http://www.bre.co.uk./filelibrary/pdf/rpts/br_443_(2006_edition).pdf).

This gives an average U-value of 34.19 ÷ 21.6, or 1.58W/m^{2}K. The windows, doors and rooflights can therefore be considered to follow the objectives of the requirement for the insulation envelope.

Annex 6.B Compensatory approach - heat loss example

6.B.0 Introduction

This annex gives an example of the compensatory approach for use in the design of conversions, extensions and alterations. This is likely to be of use where there is a need to specify one or more constructions with a U-value higher than the recommended maximum area-weighted average U-values given in either column (a) or (b) of the table to clause 6.2.9.

The examples given in this instance are for an attic conversion and for a single storey extension, however the same principles apply to other substantial alterations, extensions and conversions:

- example 6.B.1 shows use of better U-values to some elements to compensate for lack of headroom in an attic conversion where column (b) U-values apply
- example 6.B.2 shows use of better U-values to enable a larger area of glazing within an extension where column (b) U-values apply
- example 6.B.3, based on the extension shown in 6.B.2, shows a building where column (a) area-weighted U-values apply and target the heat loss limit being met by a combination of an extension which meets or exceeds column (b) U-values and fabric improvements to the existing building.

Note that this method can only be used in conversions, if the recommended U-values are met in full, not where values are being met as far as is reasonably practicable.

Separate work under the same building warrant - a single compensatory approach calculation can be carried out to cover separate areas of work to an existing dwelling provided the same assessment criteria (maximum U-values, etc) are applicable to each area of work.

6.B.1 Example: alteration to create rooms in a roof space

Note: where works are a conversion, works are subject to the U-values within column (b) in the table to clause 6.2.9.

It is proposed to form two rooms in the roof space of an existing single storey dwelling. The extra floor area created (including opening for stairway) will be 36.4m^2. A plan and section of the proposed layout is shown in the figure below. A key part of the design is to create as much headroom as possible below the new coombe ceilings. The existing rafters are only 150mm deep therefore it is difficult to achieve the recommended elemental U-value of 0.18 (see column (b) in the table to clause 6.2.9), without using branders or having an excessive thickness of insulated ceiling lining. The principal compensatory measure will be to highly insulate the attic walls that occur directly below the lowest part of the coombes. The existing gables will be provided with insulated internal wall lining to improve the U-value where the insulation envelope now occurs. The four no. 1.5m^2 rooflights installed have timber frames. The floor that will be formed at the line of the existing ceiling ties is wholly within the insulation envelope and is therefore disregarded for the purposes of this calculation.

Procedure:

- The heat loss for a ‘notional attic’ (i.e. an attic the same size and shape as the proposed attic but with its area of window/doors/ rooflights taken as a maximum 25% of the floor area) is calculated using the U-values in column (b) in the table to clause 6.2.9.
- The internal exposed surface areas of each of the elements of the proposed building insulation envelope that have different area weighted U-values are calculated.
- The heat loss for the proposed attic is calculated using proposed U-values for building elements, which may be higher or lower than those recommended in column (b) of the

table to clause 6.2.9. The percentage area of windows/doors/rooflight area as proposed may also be greater or less than 25%.

- Finally, the heat loss calculated for the proposed attic should be less than or equal to that for the 'notional' one.

Calculate the rate of heat loss from the 'notional attic' as follows:

Figure 6.1 Attic Example

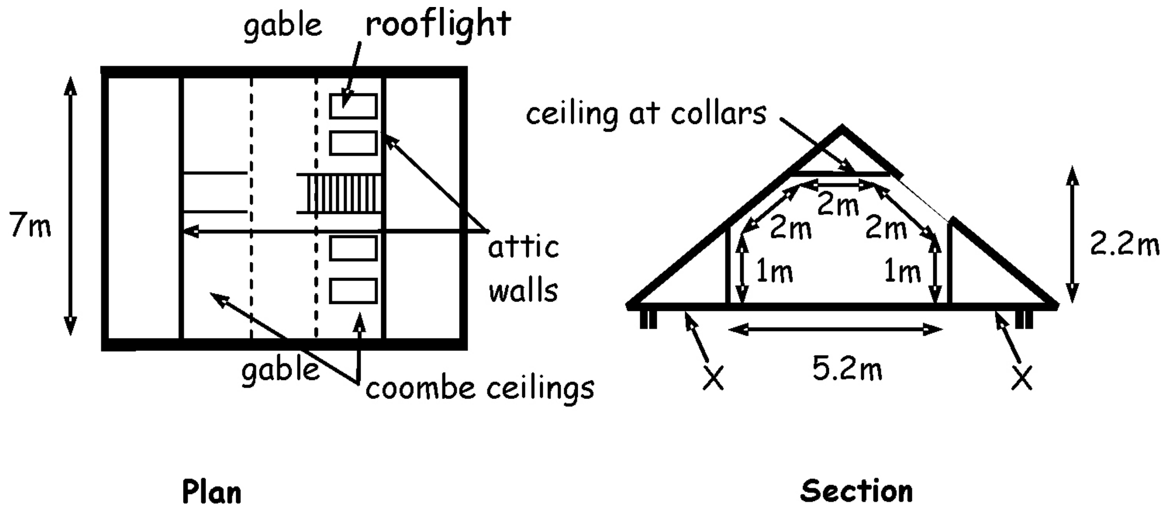


Table 6.7 Data for 'notional' attic alteration

Exposed element	Exposed surface area (m^2)		Column (b) U-value (W/m^2K)		Rate of heat loss (W/K)
Gables	19.0	x	0.22	=	4.18
Attic walls	14.0	x	0.22	=	3.08
Ceiling at collars	14.0	x	0.15	=	2.10
Coombe ceiling	18.9	x	0.18	=	3.40
Rooflights	9.1 (25%)	x	1.6	=	14.56
Total rate of heat loss				=	**27.32**

Then calculate the rate of heat loss from the proposed attic as follows:

Table 6.8 Data for proposed attic alteration

Exposed element	Exposed surface area (m^2)		Column (b) U-value (W/m^2K)		Rate of heat loss (W/K)
Gables	19.0	x	0.30	=	5.70
Attic walls	14.0	x	0.20	=	2.80
Ceiling at collars	14.0	x	0.15	=	2.10
Coombe ceiling	22.0	x	0.32	=	7.04
Rooflights	6.0 (16.5%)	x	1.6	=	9.60
Total rate of heat loss				=	**27.24**

From the above comparison, the rate of heat loss from the proposed attic (27.24) is less than that from the 'notional attic' (27.32). Proposals will comply.

Additional insulation work - the existing dwelling is of an age where there was no insulation provided in the roof space at the time of the original construction. Guidance on 'reconstruction of elements' within clause 6.2.11 recommends that where an element forming part of the insulation envelope is to be altered or dismantled and rebuilt, the opportunity should be taken to improve the level of thermal insulation.

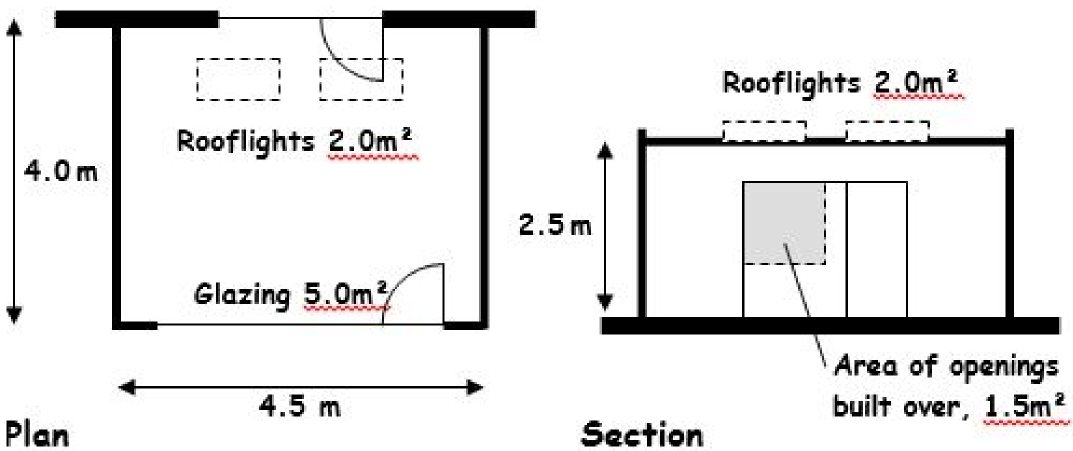
In this example, there is no technical risk or other reason which prevents the level ceiling at the eaves of the roof (see X on the section) being upgraded to achieve a U-value of 0.15 as noted in column (b) of the table to clause 6.2.9. This would therefore be required as part of the proposed works.

6.B.2 Example: single storey extension

Note: in this example, the fabric performance of the existing building allows use of the U-values within column (b) in the table to clause 6.2.9.

It is proposed to form a single room, flat-roof extension to the rear of an existing dwelling. The floor area of the extension is 18.0m^2 and it is to be built over existing openings totalling 1.5m^2 in area. A plan and section of the proposed layout is shown in the figure below. A key element of the design is provision of significant glazing (5.0m^2) to the end wall of the extension to provide views across the large garden and rooflights (2.0m^2) to maximise light into the existing dwelling. However, this area of openings is in excess of the maximum recommended in clause 6.2.9, 25% of the extension floor area plus any built-over openings. To achieve compliance with Standard 6.2, it is proposed to increase insulation U-values in floor and roof.

Figure 6.2 Single Storey extension



Procedure:

- The heat loss for a 'notional extension' (i.e. one the same size and shape as the proposed extension but with the area of window/doors/rooflights taken as a maximum 25% of the floor area plus the area of any built-over openings) is calculated using the U-values in column (b) in the table to clause 6.2.9. As no differentiation is made between U-values for doors, windows and for rooflights, the applicant may determine from which element(s) of the envelope this area is deducted.
- The internal exposed surface areas of each of the elements of the proposed building insulation envelope that have different area-weighted U-values are calculated.
- The heat loss for the proposed extension is calculated using proposed U-values forbuilding elements, which may be higher or lower than those recommended in column (b) of the table to clause 6.2.9. The percentage area of windows/doors/rooflight area, as proposed, may also be greater or less than 25%.

- The total area of exposed elements will not be the same for notional and proposed extensions where there is any area of built-over openings, which are added only to the notional extension.
- Finally, the heat loss for the proposed extension should be less than or equal to that for the 'notional' one.

Calculate the rate of heat loss from the ‘notional’ extension as follows:

Table 6.9 'Data for 'notional extension'

Exposed element	**Exposed surface area (m^2)**		**Design U-values (W/m^2K)**		**Rate of heat loss (W/K)**
Floor	18.0	x	0.18	=	3.24
Roof	18.0	x	0.18	=	3.24
External wall	26.8	x	0.22	=	5.89
Openings	4.5 (25%) + 1.5 (built over)	x	1.6	=	9.6
Total rate of heat loss				=	**21.97**

Then calculate the rate of heat loss from the proposed extension as follows:

Table 6.10 Data for proposed extension

Exposed element	**Exposed surface area (m^2)**		**Column (b) Design U-values (W/m^2K)**		**Rate of heat loss (W/K)**
Floor	18.0	x	0.15	=	2.70
Roof	16.0	x	0.15	=	2.40
External wall	26.3	x	0.22	=	5.79
Openings	5.0 + 2.0	x	1.4	=	9.80
Total rate of heat loss				=	**20.69**

From the above comparison, the rate of heat loss from the proposed extension (20.69) is less than that from the 'notional extension' (21.97). Proposals will comply.

6.B.3 Example: single storey extension subject to column (a)

Using the example above, this further exercise shows how an applicant may, where column (a) U-values apply, demonstrate compliance where an extension has an overall heat loss better than that for a column (b) notional extension, with the balance of energy savings delivered through improvement to the fabric of the existing dwelling.

The first additional step is calculating the total rate of heat loss for the more challenging column (a) notional extension, using the same process outlined in clause 6.B.2.

Table 6.11 Data for column (a) 'notional extension'

Exposed element	**Exposed surface area (m^2)**		**Column (a) Design U-values (W/m^2K)**		**Rate of heat loss (W/K)**
Floor	18.0	x	0.15	=	2.70

Exposed element	Exposed surface area (m^2)		Column (a) Design U-values (W/m^2K)		Rate of heat loss (W/K)
Roof	18.0	x	0.13	=	2.34
External wall	26.8	x	0.17	=	4.56
Openings	4.5 (25% + 1.5 (built over)	x	1.4	=	8.40
Total rate of heat loss				=	**18.0**

The exercise in clause 6.B.2 identified a proposed extension which met or improved upon the heat loss for a column (b) notional extension, as follows:

Table 6.12 Data for proposed extension

Exposed element	Exposed surface area (m^2)		Column (a) Design U-values (W/m^2K)		Rate of heat loss (W/K)
Floor	18.0	x	0.15	=	2.70
Roof	16.0	x	0.15	=	2.40
External wall	26.3	x	0.22	=	5.79
Openings	5.0 + 2.0	x	1.4	=	9.80
Total rate of heat loss				=	**20.69**

This allows the difference in rate of heat loss between the column (a) notional extension and the column (b) proposed extension to be identified.

Rate of heat loss to be addressed: 20.69 – 18.0 = **2.69 W/K**

In this example, to deliver this improvement within the existing dwelling, additional insulation of an accessible roof space is proposed.

- Roof space of $20m^2$ with 150mm mineral wool insulation between ties. Top up of 150mm insulation, laid at right angles to roof ties.

Table 6.13 Benefit of proposed improvement measure(s)

Benefit of proposed improvement measure(s)	
U-value of existing construction	$0.29W/m^2/K$
U-value of proposed construction	$0.14W/m^2/K$
Reduced rate of heat loss per m^2 of insulation	0.15W/K
Area applicable to proposed measure	$20m^2$
Total reduction in heat loss for proposed measure	**3.0W/K**

Note: Benefit of improvement measure should be supported by full material specification and U-value calculation.

Total rate of heat loss (proposed extension – improvement measures) should not exceed total rate of heat loss (column (a) notional extension).

In this case: 20.69 – 3.0 = **17.69**.

From the above comparison, the rate of heat loss from the proposed extension and improvements (17.69) is no more than that from the column (a) 'notional extension' (18.0).

The rate of heat loss from the proposed extension is also no more than for a column (b) notional extension. Proposal will therefore comply.