6.0 Introduction

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Introduction

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6.0.1 Background

Over the years changes have been made to the Scottish building regulation requirements for energy conservation. A brief history of the drivers for these changes follows:

- in the 1960s health was the main focus and minimising the occurrence of damp and mould in *housing* and other residential *buildings*;
- in the 1970s, tackling the fuel crises was the main issue and the scope of the regulations was extended to cover all heated *buildings*;
- in the 1980s to early 1990s cost effectiveness identified a need for heating controls and these were introduced for *buildings*;
- from the late 1990s to the present, ‘greenhouse gas emissions' in particular carbon dioxide and ‘global warming’ have been the drivers for regular changes;
- in this century the European Union has influenced the way that the energy standards of the Member States are set through the Directive on the energy performance of *buildings*.

The *construction* industry has a major role to play in the conservation of fuel and power and the consequential reduction of carbon emissions. Carbon dioxide emissions from the burning of fossil fuels are contributing to climate change and energy use in *buildings* are a significant source of emissions. Rising temperatures, an increased risk of flooding and sea level rise are some of the expected impacts of climate change on Scotland and the UK, but some of the worst impacts of climate change can be avoided if action is taken to reduce reliance on fossil fuels. Increased energy efficiency and promotion of renewable energy are an important element of Scotland’s strategy to tackle the threat of climate change.

6.0.2 Aims

The intention of section 6 is to ensure that effective measures for the conservation of fuel and power are incorporated in *buildings*. In addition to energy conservation provisions for the *building* fabric and the *building* services it contains, a carbon dioxide emissions standard obliges a designer to consider new *buildings* in an holistic way. In view of this, localised or *building*-integrated low and zero carbon technologies (LZCT) (e.g. photovoltaics, active solar water heating, combined heat and power and heat pumps) can be used as a contribution towards meeting this standard.

The standards and guidance given in this section are intended to achieve an improvement of around 23-28% fewer emissions on the previous standards, however nothing here prevents a *building* from being designed and *constructed* to be even more energy efficient and make greater use of LZCT. Where this occurs, both the monetary and environmental savings will be improved.

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:

- ventilation;
- combustion appliances; and
- biomass fuel storage.

6.0.3 General guidance

This section covers the energy efficiency for non-domestic *buildings*. Such *buildings* include; factories, *offices*, *shops*, warehousing, hotels, *hospitals*, hostels, and also those used for assembly and entertainment. When determining how to follow the Technical Handbook guidance for energy efficiency in *buildings*, recognition should be given to the following:

a. an *insulation envelope* is only appropriate to those parts of a *building* that are intended to be heated or cooled. N.B. Heating rated at a maximum of 25 W/m^2 of floor area and installed only for the purposes of frost protection should be disregarded, for the purposes of this guidance;

Modular and portable *buildings*

b. some concessions are given in annex 6C to modular and portable *buildings* (some of which could be *stand-alone buildings*). The flowchart in the annex gives guidance on the possible compliance routes. Note there are no concessions for *limited life buildings* which are *constructed* in a conventional manner;
c. single *storey* portable *buildings* with a floor area of not more than 30 m^2 (some of which could be *stand-alone buildings*) and first erected before 1st May 2005 can be relocated within Scotland until 30th April 2015 without further upgrading in respect of energy performance;
d. *stand-alone buildings* that are heated (see paragraphs below); and
e. work on existing *buildings* (see paragraph below).

Heated *stand-alone buildings*

The EU Directive on the Energy Performance of Buildings 2002/91/EC has introduced the category of '*stand-alone building'* and within appendix A of the Technical Handbooks a definition has been provided. The Directive exempts such *buildings* that are less than 50 m^2 in floor area from both the need to use a methodology for compliance with energy standards and also, the need to have an energy performance certificate, standards 6.1 and 6.9, respectively. The defined term not only includes detached *buildings*, but also enables thermally divided parts of a *building* with separate heating shut-down control, to be included. For *stand-alone buildings* that are less than 50m^2 in floor area, compliance with standards 6.2 to 6.8 and 6.10 must still be met. The guidance to standard 6.2 recommends that the *insulation envelope* achieves the level of performance applicable to an extension. There are no exemptions for those which are 50 m^2 or greater.

Examples of *stand-alone buildings*

Common examples of *stand-alone buildings* that could be less than 50 m^2 and which would therefore be eligible for exemption are; a detached petrol filling station kiosk, which is associated with a supermarket and heated *office* and *toilet* accommodation, within an otherwise unheated warehouse.

Work on existing *buildings*

In general, as for the other standards within Scottish building regulations, the energy standards apply to *conversions* and also *work* on existing *buildings*, such as; extensions, alterations and replacements. For certain situations however, it is either inappropriate that they apply, or the guidance to the standards is different and this is usually to meet the constraints of the existing *building*. It is advisable in the first instance to check the functional standard as sometimes a limitation removes certain classes of this type of *work*. A standard that does apply, will apply in full to the new *work* on the existing *building*, the exception to this could be where the standards are brought into effect by *conversion* and this is identified in the introduction to the guidance supporting each standard. Where the guidance that supports a functional standard varies from that for new *buildings*, this is identified towards the end of the guidance for 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 temperatures on either side differ by one 1^{0}C. It is expressed in units of Watts per square metre per degree of temperature difference (W/m^2K).

Measurements of *U-values* should be made in accordance with BS EN ISO: 8990:1996. In calculation thermal bridging may be disregarded where the difference in thermal resistance between bridging and bridged material is less than 0.1 m^2K/W. Normal mortar joints need not be taken into account in calculations for brickwork, but should be taken into account for lightweight insulating blockwork, for example.

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Taking into account guidance from BRE publication BR 443 (2006 Edition) 'Conventions for U-value calculations', individual *U-values* of *building* elements forming the *insulation envelope* should be established:

a. by using insulation to a thickness derived from manufacturers' data relating to thermal conductivities (W/m.K) and thermal transmittances (*U-values*: W/m^2K) certified by a *notified body*;
b. by using insulation to a thickness derived from the tables in Part A of the SBSA Technical Guide: 'U-values';
c. 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: 1997 or CIBSE Guide Section A3, 2006 Edition (for worked examples see Part B of the SBSA Technical Guide: 'U-values');
d. for floors adjacent to the ground and basements, by using the method outlined in Part C of the SBSA Technical Guide: 'U-values' and set out fully in BS EN ISO 13370: 1998 or CIBSE Guide Section A3, 2006 Edition;
e. for windows, doors and rooflights, by using BS EN ISO 10077-1: 2000 or BS EN ISO 10077-2: 2003, for rooflights BS EN ISO 12567-2: 2005, or the tables in Part A of the SBSA Technical Guide: 'U-values'; or λ
f. for metal cladding systems using Finite Element Analysis the method of calculation should be made in accordance with BS ISO 10211-1:1996 and BS ISO 10211-2:2001.

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/m.K). 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.

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The measurement of thermal conductivity should be made in accordance with BS EN 12664: 2001, BS EN 12667: 2001 or BS EN 12939: 2001. SBSA Technical Guide: 'U-values' gives the thermal conductivity of some common *construction* materials, but where available, preference should be given to values that are certified by a *notified body*. The additional guidance given in BRE publication BR 443 should also be followed.

6.0.6 Insulation envelope where the u-values should be ignored.

Thermal transmittance through *separating walls* or *separating floors* between 2 units in *different occupation* should be ignored, if it is likely that both parts will be heated or cooled to a similar degree.

6.0.7 Buffering effects on the insulation envelope

The following should be considered where a *building* (or part) is separated or divided from an enclosed area that:

- is neither heated nor cooled; or
- is heated or cooled to a significantly different level.

Examples of such areas could be in the first instance, an enclosed, unheated car parking garage which is adjacent to *office* accommodation and for the second case, a cold store which is adjacent to a space heated part of a *factory*. In such cases the *separating walls* and *separating floors* or dividing walls and floors should resist thermal transfer.

This can be achieved by one of the following ways:

- either by disregarding the 'buffering' effects of the area and treating the *U-value* of the element as if it were directly exposed to the external air; or
- by following the procedure in BS EN ISO 13789: 1999.

6.0.8 Roofs that perform the function of a floor

A roof of a *building* that also performs the function of a floor or similar load-bearing surface (e.g. an *access deck, escape route*, roof garden or car park), should be considered as a roof for the purpose of identifying its status with regard to the *insulation envelope*.

6.0.9 Atria

In a *building* with an atrium, the guidance given in clause 6.0.6 only applies if the atrium is unheated and totally divided from the remainder of the *building* by translucent *glazing* and doors and, if appropriate, walls and floors. In addition to this, it should not be intended that the atrium is to gain heat transfer from the surrounding *building*. In other situations involving atria, where none of the above occurs, the *insulation envelope* is at roof level (usually predominantly *glazed* with translucent material) and the atria is considered to be a part of the main *building*.

6.0.10 Annexes to guidance

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At the back of this section are annexes. These give guidance in respect of modular and portable *buildings*, calculation procedures and energy certificates.

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 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*); and
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

Section 6 has been substantially changed whilst retaining as much of the existing relevant guidance as possible. The following is a summary of the main changes that have been introduced between 1 May 2006 and 30 April 2007.

Standard 6.1 and associated guidance is entirely new and replaces the previous Building Standards Circular on Energy. The guidance presents overall carbon dioxide emissions levels for new *buildings*. The heat loss method and carbon emissions calculations methods of compliance have been replaced by the procedure in the guidance to 6.1.

The guidance supporting standards 6.2 (*Building insulation envelope*), 6.3 (Heating system), and 6.4 (Insulation of pipes, *ducts* and vessels) recommend minimum or base elemental levels (backstops). For *work* on existing *buildings* the recommended levels are generally more demanding than for new-build because in the case of new-build an overall more demanding compliance target is achieved through standard 6.1.

'Accredited Construction Details (Scotland)' are referred to in the guidance to standard 6.2 on limiting air infiltration and reducing thermal bridging. These details may be accessed from the SBSA website.

The guidance to standard 6.3 has been expanded to cover a more complete range of heating systems, including certain low and zero carbon technologies that are localised or *building* integrated.

Standards 6.5 (Artificial lighting) and 6.6 (Mechanical ventilation and air-conditioning) have been updated due to the introduction of standard 6.1 to make it compliant with the EU Directive on the energy performance of *buildings* (EPBD).

The guidance to standards 6.7 (Commissioning building services) and 6.8 (Written information) is largely unchanged.

Standards 6.9 (Energy performance certificates), 6.10 (Inspection of air-conditioning), are entirely new and are required as a result of the EPBD.

The number of annexes are reduced. The text of the former annexes on alterations, extensions and *conversions* has been integrated into the guidance to the standards (refer clause 6.0.12). Annexes which are no longer appropriate have been deleted entirely. However, where information on *U-values* has not been adapted and subsumed by the main guidance it can be accessed via the SBSA Technical Guide: 'U-values' on the SBSA web-site.

6.1 Carbon dioxide emissions

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standard

6.1

mandatory

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

(a) the energy performance is calculated in accordance with a methodology which is asset based, conforms with the European Directive on the Energy Performance of Buildings 2002/91/EC and uses UK climate data; 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;

(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, ventilation and lighting in a new *building*. It sets an overall level for maximum carbon dioxide emissions in buildings by use of a methodology which incorporates a range of parameters which will influence energy use. This means a designer is obliged to consider energy as a complete package rather than looking only at individual elements such as insulation or boiler efficiency. In other words standard 6.1 involves a 'whole *building* approach' to energy. Such an approach offers a good degree of design flexibility and favours the use of localised or building-integrated low and zero carbon technologies.

For the majority of new buildings, standard 6.1 has the greatest influence on design for energy performance, standards 6.2 to 6.10 in the main recommend only base minimum levels or back-stops to be achieved for the individual elements. To reach compliance with standard 6.1, it is usual to go beyond these back-stop levels by incorporating additional energy efficiency measures.

small stand-alone buildings

The guidance given in support of standards 6.2 to 6.8 for extensions and alterations should be followed when designing stand-alone buildings of less than 50 m^2.

Conversions

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

6.1.1 Simplified Building Energy Model (SBEM)

Simplified Building Energy Model

The Simplified Building Energy Model (SBEM) is a calculation tool which may be used with the methodology which conforms with European Directive 2002/91/EC and is recommended for use with the carbon dioxide emissions calculation. A version for use with this guidance is freely available at http://www.ncm.bre.co.uk/index.jsp.

Alternative calculation tools

It may be appropriate to use other tools with the methodology (such as using detailed simulation models), particularly where the *building* is considered to be a complex design. In this situation the verifier should be consulted early in the design process. The SBSA will give a list of other recommended calculation tools as and when they become available. The guidance given here is written in terms of the SBEM calculation tool but the principles and procedures still apply to other calculation tools.

6.1.2 Summary of procedure

Objectives

The calculated carbon dioxide emissions measured in kilograms per square metre of floor area per annum for the proposed *building* should not exceed those which are calculated for a 'notional' *building* which has the same size and shape. In broad terms, the way that this process works is described below.

TER

Input the size and shape data of the proposed *building* into a calculation methodology together with the Scottish standard package of construction and *building* services performance measures. A carbon dioxide emission rate is then generated and improved upon by using a formula which reflects the type of heating/cooling system for the *building*. This creates the target (carbon dioxide) emissions rate (TER). Having established the TER the designer then proceeds to incorporate the package of construction and *building* services performance measures which are appropriate to the proposed *building* having regard to:

- actual type(s) of fuel to be used in the *building* and CO_2 emissions; and
- the backstop measures given in sections 6.2, 6.3, 6.4, 6.5 and 6.6.

BER

Once the designer is satisfied that all the input data accurately reflects the proposed *building* design, the building (carbon dioxide) emissions rate (known as BER) is created. If BER is equal or less than TER then compliance with this guidance can be considered as having been achieved. If BER is greater than TER then the designer can improve the construction and *building* services performance measures in the proposed *building*, for example, by reducing the air permeability. Another option that would be open to the designer would be to incorporate some 'enhanced management and control' features, for example, power factor correction. Where these features are not taken account of by a calculation methodology, the designer may slightly reduce the BER.

6.1.3 The 'Notional' Building and SBEM calculation tool.

Setting up the 'notional' *building*

The 'notional' *building* can be created, once the design of a proposed *building* has reached the stage whereby the following information is known:

- orientation (location is not needed as one set of climate data applies throughout Scotland);
- overall size and shape, together with the internal layout and dimensions (see 6.0.1 for calculation of areas);

- the heated and/or cooled spaces and the activities carried out in these internal spaces; and
- the construction build-up in relation to thermal mass.

At all stages the conventions in the SBEM calculation tool manual should be read in conjunction with the specific guidance given in this clause. The version of SBEM calculation tool that is freely available has some of the input data already embedded in the software but this may not be the case with some other methodologies. In the interests of transparency, all the information needed to create the 'notional' *building* (whether user defined or embedded in SBEM calculation tool) is given in this clause.

Enhanced values and efficiencies for Scotland

Scottish weather data and embedded values within the SBEM calculation tool should always be selected. The software will automatically generate the 'notional' *building* from the information provided for the actual *building*. The following values and efficiencies are always applied to the 'notional' *building* when 'Scotland' is selected:

U-values

Exposed Element	**U-values (W/m^2K)**
Pitched roof	0.16
Flat roof	0.25
Walls	0.30
Floors including ground floors [1]	0.25
Windows, roof windows, rooflights and doors	2.2
High usage entrance doors, display windows [2] and similar *glazing*	6.0
Smoke vents	6.0
Vehicle access and similar large doors	1.5

Notes:

1. For ground floors the SBEM calculation tool will calculate a *U-value* (for an un-insulated floor) using default assumptions about the perimeter/floor area ratio. If this is 0.25 or above, the value of 0.25 will be used.
2. If it is less than 0.25, the value will be reported to the user who has the option of providing the actual perimeter/floor area ratio. If the calculated *U-value* based on the actual perimeter/floor area ratio is less than 0.25, this lower value is used.
3. Clause 6.2.1 characterises display windows.

Thermal Bridges

Type of junction	Psi value (W/mK)
Wall - ground floor junction	0.16
Intermediate floor	0.07
Wall - wall corner	0.09
Separating wall between units (applied to each unit)	0.03
Eaves (equates to insulation at ceiling level)	0.06
Lintel above window or door opening	0.21
Window or door jamb	0.05
Window sill	0.04

Window and rooflight areas

Building type	Windows and doors as % of the area of insulation envelope wall (excluding separating walls that follow 6.0.5)	Rooflights as % of area of roof [1]
Residential (Non-domestic)	30	20
Offices, shops and buildings for entertainment and assembly purposes	40	20
Industrial and storage buildings	15	20
High usage entrance doors and display windows and similar *glazing* [2][3]	as required	as required

Notes:

1. Dormer windows in a roof are included in the rooflight area.
2. SBEM calculation tool always assumes windows, doors and roof-lights the same as for the 'notional' *building*.
3. Clause 6.2.1 characterises display windows.

Air permeability

The 'notional' *building* has a air permeability of $10m^3/m^2.h$ at 50 Pa.

Solar Transmittance

Total solar energy transmittance (g-value) of *glazing* (including display windows and rooflights) should be taken as 0.65.

HVAC system efficiencies

HVAC System	Cooling SSEER [1] (cooling demand /cooling energy)	SCoP [2] (heating demand/heating energy)	Auxiliary energy (kWh/m^2)
Heating only	n/a	0.73	6.5
Air conditioning	1.67	0.83	26.6
Mechanical Ventilation	n/a	n/a	11.0

Notes:
1. SSEER is the source seasonal energy efficiency ratio.
2. SCoP is the seasonal co-efficiency of performance.

Lighting installed power density

For general lighting the following table is used to calculate the installed power density:

Lighting installed power density

Activity Area	Power Density
office , storage and industrial spaces	(illuminance / 100) x 3.75
other spaces	(illuminance / 100) x 5.2

Notes:
1. The illuminance should be appropriate to the activity area.
2. The 'notional' *building* has local manual switching.

For display lighting, take the 'notional' display lighting density appropriate to the activity (from the activity area database in the SBEM calculation tool).

User defined information

The following information should be input and should reflect the design of the proposed *building*:

a. size and shape (see clause 6.0.11);
b. activity area parameter values and classes of building services as in the actual building e.g. open plan *office*. Each space is used for the same activity (and therefore the same activity area parameter values) in the notional and the proposed *building;*
c. The 'notional' and proposed *building* should have the same orientation;
d. areas of elements;
e. construction build-up of elements to complement U-values embedded in the SBEM calculation tool.

Note:
1. any service not covered by section 6 e.g. emergency escape lighting, specialist process lighting and lifts are ignored
2. assume mains gas as the heating fuel where this is available on site otherwise oil is assumed. This should be used with the $C0_2$ emission factors in the table below.
3. assume grid mains electricity will be used as the energy source for all other *building* services.
4. thermal bridge heat losses will be based on the same geometry as the proposed *building*.

Concluding the 'notional' *building*

Work on the 'notional' *building* can be considered to be complete when an unimproved carbon dioxide emissions rate is generated. This term is known as ‘$C_{notional}$’.

6.1.4 Setting the target carbon dioxide emissions level

Establishing the target emission rate (TER)

Once the notional *building* has a carbon dioxide emissions rate '$C_{notional}$' the TER can be calculated. One of the formulae below should be selected. This should be the one that best describes the *building* services strategy of the proposed *building*.

For heated and naturally ventilated buildings (or parts thereof) use:

$TER = C_{notional} \times (1 - 0.15) \times (1 - 0.10)$

For heated and mechanically ventilated (including air-conditioned) buildings (or parts thereof) use:

$TER = C_{notional} \times (1 - 0.20) \times (1 - 0.10)$

The first multiplier of $C_{notional}$ is the carbon dioxide emissions reduction improvement factor which reflects the improvement made by this current guidance.

The second multiplier is a 10% building integrated low and zero carbon energy technology (LZCT) benchmark.

LZCT includes the following types of technologies:
- photovoltaics;
- solar water heating;
- wind turbines;
- CHP;
- district or block heating; and
- heat pumps.

This benchmark has the effect of applying a second improvement factor, it meets the spirit of European Directive 2002/91/EC and means that designers consider the incorporation of low and zero carbon technologies (LZCT) in the *building* design. Designers can choose to include more LZCT than this benchmark, although the extent to which this can be traded off against measures such as thermal insulation, is limited by the guidance to standards 6.2 to 6.6. On the other hand, designers can opt to incorporate less than 10% or even no LZCT. If they elect to do this, more energy efficiency measures will need to be incorporated in the design.

6.1.5 Setting the building carbon emission rate

The building (carbon dioxide) emissions rate (BER) is calculated by replacing the embedded values and efficiencies in SBEM calculation tool with those that the designer wishes to incorporate in the design. There are however 2 measures that restrain the flexibility of design and these are:
- Setting the *building* CO_2 emission rate, actual type(s) of fuel to be used in the *building* and allied CO_2 emissions see the table below; and
- the backstop measures given in the guidance to standards 6.2, 6.3, 6.4, 6.5 and 6.6, where appropriate.

The first of these measures is to encourage designers to select low carbon dioxide emitting fuels where possible and the second is to limit inappropriate use of LZCT.

Carbon dioxide emission factors

Fuel	**Carbon dioxide emission factor ($kgC0_2/kWh$)**
Natural gas	0.194
LPG	0.234
Biogas	0.025
Oil	0.265
Coal	0.291
Anthracite	0.317
Smokeless fuel (incl. coke)	0.392
Dual fuel appliances (mineral+wood)	0.187
Biomass [3]	0.025
Grid supplied electricity	0.422
Grid displaced electricity[1]	0.568
Waste heat [2]	0.018

Notes:

1. Grid displaced electricity comprises all electricity generated by *building* integrated power generation systems (photovoltaic (PV), Combined heat and power (CHP) etc). The associated CO_2 emissions are deducted from the total CO_2 emissions for the *building* before determining the actual *building* emission rate. Any fuel used by the *building* integrated power generation system (e.g. to power the CHP engine) must be included in the *building* CO_2 emissions.
2. Includes waste heat from industrial processes and power stations rated at more than 10MWe and with a power efficiency greater than 35%.
3. For biomass-fired systems rated at greater than 100kW output but where there is an alternative appliance to provide standby, the CO_2 emission factor should be based on the fuel of the lead boiler.
4. For systems rated at less than 100kW output, where the same appliance is capable of burning both bio-fuel and fossil fuel, the CO_2 emission factor for dual fuel should be used, except where the building is in a smoke control area, when the smokeless fuel figure should be used.
5. If thermal energy is supplied from a district or community heating or cooling system, emission factors will have to be determined based on the particular details of the scheme, but should take account of the annual average performance of the whole system (i.e. the distribution circuits, and all the heat generating plant, including any CHP, and any waste heat recovery or heat dumping).

Once the embedded values and efficiencies have been replaced to reflect the proposed design, the *building (*carbon dioxide) emissions rate (BER) can be established.

Comparison between BER and TER

If the BER is equal or less than TER then compliance with this standard can be considered as having been achieved. If it is greater, the BER should be revised, having regard to the adjustments permitted by enhanced management and control features (see clause below).

6.1.6 Adjustment of BER

Certain management features offer improved energy efficiency in practice. Where these management features are provided in the actual *building*, the BER can be reduced by an amount equal to the product of the percentages given in the table below and the CO_2 emissions for the system(s) to which the feature is applied.

Management features

Feature	Adjustment factor
Central power factor correction to achieve a power factor of at least 0.9	0.010
Central power factor correction to achieve a power factor of at least 0.95	0.025
Lighting voltage reduction management scheme	0.010
Natural ventilation control design to achieve an occupied period temperature always less than 28 $^{\circ}$C	0.05

For example, if the total CO_2 emissions in a gas heated *building* were 60kg/m²/annum and 20kg/m²/annum are due to electrical energy consumption without power factor correction, the provision of correction equipment to achieve a power factor (pf) of 0.95 would enable the BER to be reduced by 20 x 0.025 = 0.5 kg/m²/annum.The revised BER would then be 59.5 kg/m²/annum.

Credit can only be taken where the feature is applied. For example the benefit of ‘lighting voltage reduction management’ can only be taken on the buildings electrical lighting load. Similarly credit for natural ventilation control can only be taken for areas which are fully naturally ventilated without the need for any mechanical ventilation.

6.2 Building insulation envelope

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standard 6.2 mandatory	**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 purposes of frost protection; (b) communal parts of domestic buildings which will not be heated, other than heating provided solely for the purposes 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 prevent inefficient use of some of the more mature low and zero carbon technologies (LZCT); and
- to ensure that a good level of fabric insulation is incorporated especially to construction elements that would be difficult and costly to upgrade in the future.

Thermal bridging at the junctions of *building* elements and round openings in the *building* structure are quantified and embedded in the SBEM calculation tool (refer clause 6.1.1). The principal reason for this is that the heat loss through such junctions, if poorly designed and constructed can contribute as much 10% to the overall heat loss through the insulation envelope.

As fabric insulation levels improve, the heat lost through air infiltration becomes proportionally greater. For example, in a typical 1960s *building* with poorly fitted windows 20% of the total heat could be lost through air infiltration and ventilation. If the same *building* was upgraded to 2002 levels of fabric insulation but no attempt was made to upgrade the air infiltration measures then the ventilation heat losses could represent over 40% of total heat losses. Providing a balance between uncontrolled air leakage and controlled ventilation is therefore an important aspect of energy efficiency and good indoor air quality.

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

Column (a) of the table below sets out robust backstop measures. In most cases standard 6.1 will effect even better levels of thermal insulation, unless the design of a *building* involves extensive use of building-integrated or localised low and zero carbon technologies (LZCT).

Individual element U-values

Localised areas of the same type of element may be designed to give 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* or a roof void access hatch. These areas should not be any worse than the figures given in column (b) of the table below. N.B. 'repeating' thermal bridges (e.g. timber studs in a timber frame wall) are already taken in account in a BS EN ISO 6946: 1997 *U-value* calculation and should not be considered as individual element U-values.

Maximum U-values for building elements of the insulation envelope

Type of element	(a) Area weighted average value for all elements of the same type ((W/m²K)	(b) Individual elements (W/m²K)
Wall [1]	0.3 [4]	0.7
Floor [1]	0.25	0.7
Roof	0.25	0.35
Windows, doors, roof windows and rooflights [2, 3]	2.2	3.3

Notes:

1. Excluding separating walls and separating floors where thermal transmittance should be ignored.
2. Vehicle doors or similar large doors should have a maximum *U-value* of 1.5 Wm^2K.
3. There is no maximum *U-value* for display windows.
4. 0.35 for modular and portable *buildings.*

Display Windows

A display window is an area of *glazing*, including glazed doors, intended for the display of products or services on sale within the building, positioned at the external perimeter of the *building*, at an access level and immediately adjacent to a pedestrian thoroughfare. *Glazing* that extends to a height of more than 3 m above such an access level or incorporates an fixed or opening light of less than 2 m^2, should not be considered part of a display window except:

- where the size of individual products on display require a greater height of *glazing*;
- in cases of *building work* involving changes to the façade (including glazing) and requiring planning consent, where Development Control Officers should have discretion to require a greater height of *glazing*, e.g. to fit in with surrounding buildings or to match the character of the existing façade.

It is expected that display windows will be found in the type of buildings detailed below:

- shops including retail-warehouse, undertakers, show-rooms, post offices, hairdressers, shops for sale of cold food for consumption off premises.
- financial and professional services banks, building societies.
- estate and employment agencies.

- food and drink restaurants, pubs, wine bars, shops for sale of hot food for consumption off premises.

6.2.2 Areas of windows, doors, rooflights and roof windows

Due to the carbon dioxide emissions standard 6.1, there is no guidance on minimum or maximum areas for windows, doors, rooflights and roof windows in buildings. The use of a methodology for establishing compliance with standard 6.1 provides a more equitable approach to the conflicting energy issues of heatloss, solar gain, natural lighting, and artificial lighting. In the case of shell and fit out buildings that are not the subject of a staged building warrant, the areas should follow the guidance given in the following clause.

6.2.3 Shell and fit out buildings

New buildings which have been constructed as a shell under one building warrant for later fit out under a separate warrant should meet the maximum U-values for *building* elements of the *insulation envelope* as given in column (a) of the table below.

Localised areas of the same type of element may be designed to give 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. These areas should be better than the figures given in column (b) of the table below.

Maximum U-values for building elements of the insulation envelope

Type of element	(a) Area weighted average value for all elements of the same type ((W/m^{2}K)	(b) Individual elements (W/m^{2}K)
Wall [1]	0.25	0.7
Floor [1]	0.22	0.7
Roof	0.16	0.35
Windows, doors, roof windows and rooflights [2, 3]	1.8	3.3

Notes:

1. Excluding separating walls and separating floors where thermal transmittance should be ignored.
2. There are no limits on display windows which are characterised by clause 6.2.1.

The opening areas in the *building* 'shell' should be designed in accordance with the table below.

Maximum windows, doors and rooflight areas

Building Type	Windows and doors as % of the area of exposed wall	Rooflights as % of area of roof
Residential (non-domestic)	30	20
Offices, shops and buildings for entertainment and assembly	40	20
Industrial and storage buildings	15	20
High usage entrance doors and display windows [1], and similar *glazing*	As required	As required

Notes:

1. There are no limits on display windows which are characterised by clauses 6.2.1.

It is advisable to consult with the verifier of the relevant local authority on shell and fit out issues at an early stage with the development. In some instances it may be advisable to apply for a 'staged building warrant'.

6.2.4 Resisting heat loss through thermal bridging

The *insulation envelope* of the *building* should be constructed in such a way that there are no substantial thermal bridges or gaps where the layers of insulation occur. Significant in-use energy consumption can occur, through incorrect detailing at both the design stage or poor construction *work*. The key areas of concern are:

- within *building* elements;
- at the junction between *building* elements; and
- at the edges of *building* elements where openings in the structure are formed.

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SBEM calculation tool referred to in the guidance to standard 6.1 takes account of thermal bridges, giving:

- onerous default figures for ‘no information’;
- less onerous default figures for designs that follow ‘Accredited Construction Details (Scotland)’; or
- Accurate figures from ‘numerical modelling’.

6.2.5 Limiting air infiltration

All *building* fabric will allow a certain degree of air leakage. It is widely recognised that it is impossible to make the *insulation envelope* 100% airtight. Where it is desirable to either vent or ventilate the *building* fabric to the outside air (to allow moisture due to either precipitation or condensation to escape), this should be designed into the construction. Reliance on fortuitous ventilation should be avoided. Measures should be introduced however, to reduce unwanted air leakage and thereby prevent an increase in energy use within the heated part of the *building*.

The guidance given here should not be used to compromise ventilation required for:

- health of the occupants of the *building* (section 3);
- any smoke control system (section 2); or
- combustion appliances (section 3).

The main principle of limiting air infiltration is to provide a continuous barrier to air movement around the *insulation envelope* and thereby reduce external air paths into each of the following:

- the inside of the *building*;
- the internal *building* elements;
- the 'warm' side of the insulation; and
- spaces between the component parts of exposed *building* elements, where such parts contribute significantly to the thermal performance of the element.

Accredited Details

Correct *cavity barrier* design for the purposes of structural fire precautions, with airtight materials can often contribute to achieving this objective. One approach to addressing these issues would be for non-domestic buildings of domestic type construction to be designed and built to 'Accredited Construction Details (Scotland)'.

Vertical Shafts

In buildings other areas that need consideration are common stair entrances and shafts which extend through most of the floors (e.g. lift and common stair enclosures).

Air-tightness

The move to methodology-based energy standards for new buildings means that improving the air-tightness of a *building* can allow greater design flexibility using other traditional energy efficiency measures and still allow the carbon dioxide standard in 6.1 to be met.

6.2.6 Air-tightness testing

An air-tightness industry is not yet fully established. In order to allow testing procedures in Scotland to develop at a rate that is manageable to industry, the guidance below recommends that testing need only be carried out when better than routine air-tightness levels are declared at the building warrant application stage.

The following points will assist in establishing if air-tightness testing should be carried out:

- if the *building* is designed and built following the guidance in 'Accredited Construction Details (Scotland)' the input data to the methodology for the proposed *building* (see clause 6.1.5) should be taken as air permeability equals $10m^3/m^2.h$ at 50 Pa and testing is not considered necessary; or
- if the *building* is not designed and built following the guidance in 'Accredited Construction Details (Scotland)', the input data to the methodology (see clause 6.1.5) for the proposed *building* should be taken as air permeability equals $15m^3/m^2.h$ at 50 Pa and testing is not considered necessary; or
- if the input data to the methodology (see clause 6.1.5) for the proposed *building* is that the air permeability will be less than $10m^3/m^2.h$ at 50 Pa, air-tightness testing should be carried out to justify that this more demanding level is being achieved on site.

Note, air-tightness testing can be used to justify any input data to the methodology if air permeability falls in between 10 and $15m^3/m^2.h$ at 50 Pa, and the designer does not wish to default to a figure of $15m^3/m^2.h$ at 50 Pa in the proposed *building*.

Frequency of testing multiple units

Where a *building* warrant consists of multiple units of the same construction, with each unit of less or equal than 150 m^2 in floor area, only 1 in 20 units or part thereof, needs be tested as it can be considered that all units will have similar build standards. The verifier should have the opportunity to select the units to be tested. Where the units have a floor area greater than $150m^2$ all units should be tested.

For detailed guidance on air tightness reference should be made to BR 448: Air Leakage in commercial and public buildings, and CIBSE Technical Memorandum 23 (TM23): Testing buildings for air leakage.

6.2.7 Conversion of unheated buildings

A *building* that was originally designed to be unheated in most instances has the greatest void to fill in terms of energy efficiency. Heating such buildings will adversely affect energy efficiency and because of this, the most demanding of measures are recommended when conversion occurs. Where conversion of a *building* that was previously designed to be unheated is to be carried out, it is appropriate to treat the *building* as if it were an extension to the insulation envelope of a non-domestic *building* and follow the guidance given in clause 6.2.8. This category also includes conversion of buildings with heating rated at a maximum of 25 W/m^2 floor area and installed solely for the purposes of frost protection.

6.2.8 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 either negligible, none whatsoever or in some circumstances even an improvement. In view of this, a less demanding approach is recommended which at the same time still ensures that some overall improvements are being made to the existing *building* stock.

Where an extension is formed and/or alterations are being made to the *building* fabric at the same time at the conversion, the guidance given in clause 6.2.10 to 6.2.12 should be also followed.

Where conversion of a heated *building* is to be carried out, the *insulation envelope* should be examined and upgraded (if necessary) following the table:

Maximum U-values for building elements of the *insulation envelope*

Type of element [1]	Area-weighted average value for all elements of the same type (W/m^2K)
Wall [2]	0.70
Floor [2]	0.70
Roof [2]	0.35
New and replacement windows, doors, roof windows and roof-lights [3, 4]	1.80

Notes:

1. This excludes separating walls and separating floors where thermal transmittance should be ignored.

2. Where upgrading *work* is necessary to achieve the U-values reference should be made to 'Reconstruction of elements' in clause 6.2.9 and more demanding U-values achieved, where appropriate.
3. There are no limits on display windows which are characterised by clause 6.2.1.
4. Refer to table in clause 6.2.10 for maximum areas of windows, doors and rooflights.

6.2.9 Conversion of historic buildings

Historic Buildings

With historic buildings, the energy efficiency improvement measures that should be invoked by conversion can be more complex. The number of these types of buildings in the country is finite. The majority of them have visual features that are not only worth preserving but the industry of today can have difficulty in replicating such construction.

No specific guidance is given here on this subject. Each case will have to be dealt with on its own merits. Any improvements to the fabric insulation of the *building* will often depend on whether or not the installation *work* can be carried out using a non-disruptive method. For example, insulating the ceiling of an accessible *roof space*. In certain cases, buildings are given historic status because of the features that exist on one particular façade and in these circumstances it may be possible to make some improvements to other less critical elevations or areas. In all cases the ‘do nothing’ approach should not be considered initially. Innovative but sympathetic and practical solutions on energy efficiency, which are beyond the scope of this guidance, can often result in an alternative package of measures being developed for a historic *building*. This could consist of reducing carbon dioxide emissions through improvements to the heating system (refer standards 6.3, 6.4), the lighting system (refer standard 6.5) or incorporation of LZCT (including biomass boilers and heat pumps). Consultation on such matters at an early stage with both the verifier and the Development Control Officer of the relevant local authority is advisable.

6.2.10 Extensions to the insulation envelope

Extensions

The majority of the construction for an extension will be new-build and seldom will there be the need to *construct* to a lesser specification as is sometimes the case for alteration *work*. At the interface of the existing and new construction however, it may be appropriate to build to a slightly lower specification to allow the transition to occur. e.g. proprietary metal ‘wall starter’ ties where existing brickwork stops and new cavity blockwork begins. It will still be necessary to ensure that the other building standards are met with regard to the transitionary construction.

U-values

Where the insulation envelope of a *building* is extended, the new *building* fabric should be designed in accordance with the following table:

Maximum U-values for building elements of the *insulation envelope*

Type of element, (excluding separating walls and separating floors where thermal transmittance should be ignored.	(a) Area-weighted average value for all elements of the same type (W/m²K)	(b) Individual element U-value (W/m²K)
Wall [2]	0.27	0.7
Floor [2]	0.22	0.7
Pitched-roof insulation between ceiling ties or collars [2]	0.16	0.35
Flat roof or pitched roof insulation between rafters or roof with integral insulation [2]	0.20	0.35
Windows, doors, roof windows and roof-lights [1] [2]	1.8	3.3

Notes:

1. There are no limits on display windows (Clause 6.2.1. characterises the term)
2. The U-values for the elements involved in the *work* may be varied provided that the area-weighted *U-value* of all the elements in the extension is no greater than that of a 'notional' extension which is the same size and shape as one designed to these elemental measures when the area of openings, in the walls (excluding separating walls where it considered that zero heat loss occurs) and roof of the 'notional' *building* are the same as the table below. An example of this approach is given in Annex 6B.

Where the *insulation envelope* of a *building* is extended, the new opening areas should be designed in accordance with the table below.

Maximum windows, doors and roof-light areas

Building Type	Windows and doors as % of the area of exposed wall	Roof-lights as % of area of roof
Residential buildings (non-domestic).	30	20
Offices, shops and buildings for entertainment and assembly purposes.	40	20
Industrial and storage buildings.	15	20
High usage entrance doors and display windows and similar *glazing* .	As required	As required

Notes:

1. There are no limits on display windows which are characterised by clause 6.2.1.

6.2.11 Thermal bridging and air infiltration for existing buildings

The elements involved in the *work* should follow the guidance in clauses 6.2.4 and 6.2.5. In addition BR 262 'Thermal Insulation, avoiding risks' 2002 edition, can be followed.

It should be noted that the methodology (SBEM calculation tool) does not apply to this type of *work*, and also air-tightness testing is not necessary.

6.2.12 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 buildings), it may be necessary to adopt alternative energy efficiency measures which are appropriate to the amount of alteration *work* being undertaken.

Extending the *insulation envelope*

Reference should be made to the guidance on extensions to the *insulation envelope* (clause 6.2.10.) for alterations that involve increasing the floor area and/or bringing parts of the existing *building* that were previously outwith the *insulation envelope* into the occupied part of the *building*. Examples of such *work* could be, changing a *roof space* , part of an unheated warehouse or a deep solum space into *office* accommodation:

- 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 alterations, for example, insulation to parts of the ceiling ties at the eaves;
- in the case of an unheated warehouse, this will usually involve extending the *insulation envelope* to include, the existing floor, perimeter walls and the roof/ceiling to the new *office* area; 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 *office* 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 4 m^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 0.70 W/m^2K and for a roof, not worse than 0.35 W/m^2K.

Infill of large openings

The infill of an existing opening of greater area (than approximately 4 m^2) in the building fabric should have a *U-value* which achieves those in column (a) of the table to 6.2.10. 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*.

Insulation envelope formed from internal elements

Where the alteration causes an existing internal part or other element of a *building* to form the *insulation envelope*, that part of the *building* (including any infill construction) should have U-values which achieve those in column (a) of the table to clause 6.2.10. This will most likely occur where a part of a *building* is permanently removed as a phase of the alteration *work*. 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*. Where this occurs at a *boundary*, no upgrading is necessary 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 (a) of the table to clause 6.2.10. Where the *work* relates only to 1 or 2 replacement windows a centre pane U–value for each window no higher than 1.2 W/m^2K is acceptable. An example of a compensatory approach for several windows, doors and rooflights is given in annex 6A. For secondary *glazing*, an existing window, after alteration should achieve a *U-value* of about 3.5 W/m^2K.

Display windows

There are no limits imposed on display windows which are characterised by clause 6.2.1.

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 (a) of the table to clause 6.2.10 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 that certain constructions are easier to upgrade than others. 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 possible for a *building* 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 *building* 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 W/m^2K and in the case of a wall or floor, 0.70 W/m^2K.

When alterations are carried out, attention should still be paid to limiting thermal bridging at junctions and around windows, doors and rooflights and also limiting air infiltration (see clause 6.2.11). As far as alterations are concerned only the *work* that forms the alteration and the impact of that *work* on the existing *building* need be considered.

6.3 Heating system

standard

6.3

mandatory

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;

(b) heating provided solely for the purpose of frost protection; or

(c) individual solid-fuel or oil-firing stoves or open-fires, gas or electric fires or room heaters (excluding electric storage and panel heaters) provided as secondary heating in *domestic buildings*.

6.3.0 Introduction

In the design of *buildings*, the energy efficiency of the heating plant is an important part of the package of measures which contributes to the overall *building* carbon dioxide emissions. In practice the backstop levels for appliance efficiencies and controls will normally be exceeded to achieve compliance with standard 6.1. for new *buildings*.

Good control of space heating is essential for conservation of energy in *buildings*, as without it, the potential of energy efficient heating plant cannot be realised. Generally the system should have sufficient zone, time and temperature controls to ensure that the heating system only provides the desired temperature when the *building* is occupied. Such operating controls can be overridden however, when heating is needed to protect the *building's* structure, services or contents from frost or condensation damage.

There are two efficiency issues which go beyond the guidance to the standard. These are:

- a heating system boiler should be correctly sized to ensure energy efficiency; and
- where future heating capacity is required consideration should be given to providing additional space for extra plant. The pipe-work or ductwork should be configured to allow for the future loading.

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 Efficiency and credits

Appliances installed in a *building* should be energy efficient.

heating efficiency credits

Designers may wish to consider using heating efficiency credits when designing systems incorporating boilers, warm air heaters, radiant heaters, heat pumps, and domestic hot water systems to exceed the minimum efficiency specified. Examples of how this is achieved is given in annex F.

The heat generator is a device for converting fuel and or electricity into heat, e.g. a boiler or radiant panel.

The heat generator efficiency is the ratio of useful heat output to energy input in the fuel (based on gross calorific value) or electricity delivered to the heat generator as determined by the testing methods for that type of heat generator.

The heat generator seasonal efficiency is the estimated seasonal ratio of heat input to heat output from the heat generator. This will depend on the heat generator efficiency and the operating mode of the heat generator over the heating season. For example in the case of boilers it is a weighted average of the efficiencies of the boiler at 30% and 100% of the boiler output. For other technologies the heat generator seasonal efficiency may be the same as the heat generator efficiency. Annex 6.E shows a way of determining seasonal boiler efficiency.

The effective heat generator seasonal efficiency equals the heat generator seasonal efficiency + heating efficiency credits, which are awarded for the provision of specific measures. The effective heat generating seasonal efficiency is the minimum efficiency that should be met by the heat generator and associated heating efficiency credits.

6.3.2 Appliance efficiency

The following tables recommend efficiencies for:

- minimum boiler seasonal efficiency for heating plant;
- minimum thermal efficiency for gas and oil fired warm air systems and radiant heaters;
- co-efficient of performance (COP) for heat pumps,
- minimum thermal efficiencies for domestic hot water systems; and
- m aximum permissible specific fan power for air distribution systems.

Boiler seasonal efficiency in new *buildings*

Fuel Type	Boiler system	Minimum Boiler Seasonal Efficiency (based on gross calorific value)
Gas (Natural) Gas (LPG) Oil	Single Multiple	84% 80% for any individual boiler and 84% for the overall multi-boiler system.

Effective heat generating seasonal efficiencies and boiler seasonal efficiency in existing *buildings*

Fuel Type	Minimum effective heat generating seasonal efficiency (based on gross calorific value)	Minimum boiler seasonal efficiency (based on gross calorific value)
Gas (Natural)	84%	80%
Gas (LPG)	85%	81%
Oil	86%	82%

Gas and oil firing warm air systems minimum thermal efficiency

System	Minimum thermal efficiency (based on gross calorific value)
Gas firing forced convection heater without a fan complying with EN 621	80%
Fan assisted gas-firing forced convection complying with EN 1020	80%
Direct gas firing forced convection heater complying with EN 525	90%
Oil firing forced convection	80%

Radiant heaters minimum thermal efficiency

System	Minimum thermal efficiency (based on gross calorific value)
Luminous (flueless)	85.5%
Non-luminous (flueless)	85.5%
Non-luminous (*flued*)	73.8%
Multi-burner radiant heaters	80%

Heat pump Co-efficient of Performance (COP)

System	Minimum Heating COP (at design condition)
All types except absorption heat pumps and gas engine heat pumps	2.0
Absorption heat pumps	0.5
Gas engine driven heat pumps	1.0

Domestic hot water systems

System Type		Minimum thermal efficiencies (based on gross calorific value)
Direct - firing	Natural gas	73%
	LPG - firing	74%
	Oil - firing	75%
Indirect - firing (dedicated hot water boiler)	Natural gas	80%
	LPG - fired	81%
	Oil - fired	82%

Notes:

1. There is no minimum thermal efficiency specified for electric domestic hot water heaters.

Air distribution systems

System Type	**Maximum permissible specific fan power (Watts/(litre/s))**
Central mechanical ventilation including heating and heat recovery	2.5 (3.0)
Central mechanical ventilation with heating.	2.0 (2.5)
All other central systems	1.8 (2.0)
Local ventilation only units within the local area, such as window/wall/roof units, serving one *room* or area	0.5
Local ventilation only units remote from the area such as ceiling void or roof mounted units, serving one *room* or area	1.2 (1.5)
Other local units, e.g. fan coil units	0.8

Notes:

1. For existing *buildings* the maximum permissible specific fan power is given in brackets.

6.3.3 CHPQA Quality Index (CHP(QI))

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CHPQA is a scheme under which registration and certification of CHP schemes are carried out in accordance with the criterion for good quality CHP.

This is an indicator of the energy efficiency and environmental performance of a CHP scheme, relative to the generation of the same amounts of heat and power by separate, alternative means.

The required minimum combined heat and power quality index for all types of CHP should be 105. There is no minimum combined heat and power quality index specified for electric (primary) heating. The CHP unit should operate as the lead heat generator and be sized to supply no less than 45% of the annual heating demand.

CHP may be used as the main or supplementary heat source in community heating or district heating schemes. In calculating the total CO_2 emissions for a new building, the following data should be entered into the SBEM calculation tool.

- The proportion of the annual heat demand (H) supplied from the CHP plant (P). This is needed as the CHP unit is normally sized below the peak heat demand of the building and will also be out of service for maintenance purposes.
- The overall efficiency ratio of the CHP plant (E) = annual useful heat supplied + annual electricity generated(net of parasitic electricity use) divided by the annual energy of the fuel supplied(in gross calorific value terms).
- The heat to power ratio of the CHP plant (R) = annual useful heat supplied divided by annual electricity generated (net of parasitic electricity use).

From these parameters, the SBEM calculation tool (or other detailed simulation model) will calculate the CO_2 emissions in the heat supplied from the CHP plant using an emissions factor for the electricity generated by the CHP of 568g/kWh applied to the annual total of electricity generation.

The annual carbon dioxide emissions for the heat supplied by a CHP plant (assuming gas-fired) = ((H x P)/E)+(H x P)/(R x E)) x 194 – ((H x P)/R) x 568.

Carbon dioxide emissions are in kg for the heat demand H in MWh where the terms H, P, E and R are defined above.

The CO_2 emissions for the balance of heat supplied by the boilers is then calculated by the SBEM calculation tool as for a boiler only system.

6.3.4 Boiler plant controls

When installing boiler plant in new *buildings* the following controls package in the table below should be installed. (For electrical boilers heating controls refer clause 6.3.6)

Minimum controls for new boilers or multiple-boilers systems (depending on boiler plant output or combined boiler plant output).

Boiler plant output and controls package	Minimum controls
Less than 100 kW (Package A)	Timing and temperature demand control which should be zone-specific where the *building* floor area is greater than 150 m^2. Weather compensation except where a constant temperature supply is required.
100 - 500 kW (Package B)	Controls package A above plus: Optimal start/stop control is required with night set-back or frost protection outside occupied periods. Boiler with two stage high/low firing facility or multiple boilers should be installed to provide efficient part-load performance. For multiple boilers, sequence control should be provided and boilers, by design or application, should have limited heat loss from non-firing modules, for example by using isolation valves or dampers. Individual boilers, by design or application, should have limited heat loss from non-firing modules, for example by using isolation valve or dampers.
Greater than 500 kW (Package C)	Controls package A and B above plus: The burner controls should be fully modulating f or gas-fired boilers or multi-stage for oil-fired boilers.

6.3.5 Heat pump controls

For minimum controls provisions where space heating is provided by heating only heat pumps or reverse cycle heat pumps in new *buildings,* reference should be made to the control packages given in the following table:

Source	System	Minimum controls package
All types.	All technologies.	On/off zone control. If the unit serves a single zone, and for *buildings* with a floor area of 150m ^{2} or less the minimum requirement is achieved by default time control.
Air to air.	Single package.	Controls package for all types above plus; Heat pump unit controls to include; Control of room air temperature (if not provided externally). Control of outdoor fan operation. Defrost control of external airside heat exchanger. Control for secondary heating (if fitted).
Air to air.	Split system Multi-split System. Variable Refrigerant flow system.	Controls package for all types above plus; Heat pump unit controls to include; Control of room air temperature (if not provided externally). Control of outdoor fan operation. Defrost control of external airside heat exchanger. Control for secondary heating (if fitted).
Water or ground to air.	Single package energy transfer systems (matching heating/cooling demand in buildings).	Controls package for all types above plus; Heat pump unit controls to include; Control of room air temperature (if not provided externally). Control of outdoor fan operation for cooling tower or dry cooler (energy transfer systems). Control for secondary heating (if fitted) on air to air systems. Control of external water pump operation.
Air to water. Water or ground to air.	Single package. Split package.	Controls package for all types above plus; Heat pump unit controls to include; Control of water pump operation (if not provided externally). Control of outdoor fan operation for cooling tower or dry cooler (energy transfer systems). Control for secondary heating (if fitted). Control of external water pump operation.
Gas engine driven heat pumps.	Multi-split. Variable refrigerant flow.	Controls package for all types above plus; Heat pump unit controls to include; Control of room air temperature (if not provided externally). Control of outdoor fan operation. Defrost control of external airside heat exchanger. Control for secondary heating (if fitted).

Notes:

1. For all systems in the table above, additional controls should include room thermostats (if not integral heat pump) to regulate the space temperature and interlocked with the heat pump operation.

6.3.6 Electric Heating Controls

When installing electric boiler or primary and secondary electric heating the following controls package in the table below should be installed:

Electric Boiler Controls

System	Controls
Boiler temperature control.	The boiler should be fitted with a flow temperature control and be capable of modulating the power input to the primary water depending on space heating conditions. [1] *Buildings* with a total usable floor area up to 150m^2 should be divided into at least two zones with independent temperature control. For *buildings* with a total usable floor area greater than 150m^2, sub zoning of at least two space heating zones must be provided, temperature each having separate timing and temperature controls, by either; (a) multiple heating zone programmers; or (b) a single multi-channel programmer.
Zone temperature control.	Separate temperature control of zones within the *building* [1], using either; (a) room thermostats or programmable room thermostats in all zones; (b) a room thermostat or programmable room thermostat in the main zone and individual radiator controls such as thermostatic radiator valves (TRVs) on all radiators in the other zones; or (c) a combination of (a) and (b) above.
Time control of space and water heating	Time control of space and water heating should be provided by either; (a) a full programmer with separate timing to each circuit; (b) two or more separate timers providing timing control to each circuit; or (c) programmable room thermostat(s) to the heating circuit(s), with separate timing of each circuit.

Notes:

1. An acceptable alternative to this is any boiler management control system that meets the specified zoning, timing and temperature requirements.

Primary and secondary electric heating system controls (other than electric boilers)

System	Controls
Electric warm air system	Time and temperature control, either integral to the heater system or external: (a) a time switch/programmer and room thermostat; or (b) a programmable room thermostat. For *buildings* with a total usable floor area greater than 150m ^{2} more than one space heating circuit should be provided, each having separate timing and temperature control: (a) multiple heating zone programmers; or (b) a single multi-channel programmer.
Electric radiant heater	Zone or occupancy control. Connection to a passive infrared detector (electric radiant heaters can provide zone heating or be used for a scheme). Common electric radiant heaters include the quartz or ceramic type.
Panel/skirting heater	Local time and temperature control heater: (a) Time control provided by a programmable time switch integrated into the appliance or a separate time switch; or (b) Individual temperature control provided by integral thermostats or by separate room thermostat (Panel heater systems provide instantaneous heat).
Storage heaters	Charge control : automatic control of input charge (ability to detect the internal temperature and adjust the charging of the heater accordingly).
	Temperature control : manual controls for adjusting the rate of heat release from the appliance such as adjustable damper or some other thermostatically controlled means.
Fan/fan convector heaters	Local fan control : a switch integrated into the appliance or a separate remote heaters switch.

6.3.7 Domestic hot water heating controls

Although this guidance refers only to non-domestic *buildings*, hot water systems are generally referred to as 'domestic' hot water (DHW) systems.

A DHW system should have controls that will switch off the heat when the water temperature required by the occupants has been achieved and during periods when there is no demand for hot water. The following DHW controls package in the table below should be installed.

Gas/oil firing systems

Systems	Controls
Direct	Automatic thermostat control to shut off the burner/primary heat supply when the desired temperature of the hot water has been reached.
	Time control.
Indirect	Automatic thermostat control to shut off the burner/primary heat supply when the desired temperature of the hot water has been reached.
	High limit thermostat to shut off primary flow if system temperature too high.
	Time control.

Electric DHW systems

Control system	Point of use	Locally	Central	Instant aneous
Automatic thermostat control to interrupt the electrical supply when the desired storage temperature has been reached.	Yes	Yes	Yes	No
High limit thermostat (thermal cut-out) to interrupt the energy supply if the system temperature gets too high.	Yes	Yes	Yes	No
Manual reset in the event of an over temperature trip.	Yes	Yes	Yes	No
A 7-day time-clock or Building Management System (BMS) interface should be provided to ensure bulk heating of water using off peak electricity.	No	Yes	Yes	No
High limit thermostat (thermal cut-out) to interrupt the energy supply if the outlet temperature gets too high. [1]	No	No	No	Yes
Flow sensor that only allows electrical input should sufficient flow through the unit be achieved.	No	No	No	Yes

Notes:

1. Outlet temperature is controlled by rate of flow through the unit.

A DHW system (other than a system with a solid fuel boiler) should have controls that will switch off the heat when the water temperature required by the occupants has been achieved and during periods when there is no demand for hot water. In the case of DHW central heating systems this thermostat should be interconnected with the other controls which are needed to form a boiler interlock.

www.sedbuk.com
www.boilers.org.uk

Vented copper hot water storage vessels associated with the system should meet the heat loss and heat exchanger requirements in BS 1566: 2002.

6.3.8 Space heating controls (general)

Where the space heating is to be intermittent and does not make use of off-peak electricity, the system should only operate when the *building* is normally occupied or is about to be occupied.

6.3.9 Work on existing buildings

Conversions

Where *conversion* of a *building* that was previously designed to be either heated or unheated is to be carried out, the guidance to 6.3.1 to 6.3.3 and 6.3.6 to 6.3.7 is appropriate to any new appliances or heating system installations.

In many cases heating system improvements to historic *buildings* will be more feasible than any other energy efficiency measures for example 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.

Alterations

Where an entirely new or replacement space heating/DHW system is being installed in an existing *building* the guidance in 6.3.1 to 6.3.3 and 6.3.6 to 6.3.7 should be followed.

part systems

If a heating and/or DHW system is being replaced in part, or being extended, the guidance 6.3.1 to 6.3.3 and 6.3.6 to 6.3.7 should be followed but only as it affects the new or replaced components of the system. Such alterations should not allow the heating system as a whole to be downgraded in terms of energy efficiency or compromised from a safety point of view.

6.4 Insulation of pipes, ducts and vessels

contents

standard

6.4

mandatory

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;

(c) pipes, *ducts* or vessels that form part of an isolated industrial or commercial process; or

(d) cooled pipes or *ducts* in *domestic buildings*.

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 from such equipment; or
- 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* must be improved to as close to the requirement 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 and ducts

Pipes and *ducts* used for space heating and space cooling (including pipes carrying chilled water and refrigerants) should be thermally insulated to reduce heat loss in the case of the former and heat gain in the case of the latter. This will not be necessary where the pipes or *ducts* always contribute to the heating or cooling demands of the *room* or space and the pipes or *ducts* are located at a height of 3 m or less above the floor.

Pipes that are used to supply hot water within a *building* should be insulated against heat loss. This is to conserve heat in the hot water pipes between frequent successive draw-offs.

Insulation for such pipes and *ducts* may be provided by following the guidance given for 'environmental thickness' in BS 5422: 2001 'Methods for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range – 40°C to + 700°C'.

It is not necessary to follow any of the above guidance on pipe and *duct* insulation if the installation is part of a stand-alone system that serves only an industrial or commercial process.

The *building* design should be considered at an early stage in the development to ensure the complete insulation of pipe and *ducts* where such services pass through or around structural *building* components, floor joists, for example.

6.4.2 Insulation of vessels

A hot water storage vessel should be insulated against heat loss. This can be achieved by following the guidance for 'environmental thickness' given in BS 5422: 2001. The pipes that connect to the vessel, the vent pipe and primary flow and return, for example, should also be insulated to a distance of about 1 m back from their points of connection (in addition to the guidance above on pipe insulation).

Unvented hot water systems

Where an unvented hot water system is installed, additional insulation should be considered to reduce the heat loss that can occur from the safety fittings and pipework. Such insulation should not compromise the safe operation of the system, including the visibility of warning discharges.

6.4.3 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.

6.5 Artificial and display lighting

contents

standard 6.5 mandatory	**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*; (b) communal areas of *domestic buildings*; or (c) alterations in dwellings.

6.5.0 Introduction

Artificial and display lighting can account for a substantial proportion of the electricity used within a *building*. Appropriate lighting design (including use of natural daylight) can not only reduce CO_2 emissions and associated running costs, but also reduce internal heat gains and lessen any need for air conditioning.

There are issues which go beyond the guidance that designers may wish to consider;

- when designing a lighting system consideration should be given to the advances in lighting technology, particularly with light emitting diodes technology (LED); and
- the system design should accommodate future upgrading with minimal disruption to the *building* fabric and services.

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).

6.5.1 Artificial lighting efficiency

A *building* with a floor area of more than 50 m^2 and installed with artificial lighting should have general purpose artificial lighting systems which are designed to be energy efficient. It is not necessary for this to apply to either emergency lighting (see section 2: Fire) or specialist process lighting which is intended to illuminate specialist tasks within a space, rather than the space itself. Examples of specialist process lighting are, theatre spotlights, lighting used for the recording process in TV studios and lighting in *hospital* operating theatres.

www.ncm.bre.co.uk

The lighting design should be completed in accordance with the advice and guidance given in the Society of Light and Lighting (CIBSE) Code for Lighting 2002. The Simplified Building Energy Model (SBEM) calculation tool will take account of carbon dioxide emissions attributed to them and this will encourage energy efficient lighting systems.

6.5.2 Display lighting efficiency

A display lighting system installed in a building with a floor area of more than 50 m^2 should be designed to be energy efficient.

Display lighting is artificial lighting that:

- highlights a merchandising display (e.g. in retail premises);
- highlights an exhibit (e.g. in a museum or art gallery);or
- is used in spaces intended for public entertainment (e.g. dance halls, auditoria and cinemas), but excludes any specialist process lighting within the space.

Due to the nature and purpose of display lighting, it is often not possible to achieve the levels of energy efficiency that can be reached with general purpose artificial lighting. Paragraphs, a. and b. below however, give two alternative ways of achieving the objectives of the guidance:

a. where the installed lighting capacity comprises lighting fittings with lamps having an average initial (100 hour) efficacy of not less than 15 lumens per circuit watt;
b. where at least 95% of the display lighting capacity in circuit Watts (i.e. the power consumed by lamps, their associated control gear and power factor correction equipment) is provided by lighting fittings using either compact and tubular fluorescent, metal halide, tungsten halogen or high pressure sodium lamps of any type and rating with an efficacy greater than 15 lumens per circuit Watt.

6.5.3 Controls for artificial and display lighting

Every artificial lighting system in a *building* that has a floor area of more than 50 m^2 should have controls which encourage the maximum use of daylight and minimise the use of artificial lighting during the times when *rooms* or spaces are unoccupied. It is not necessary for this to apply to either emergency lighting (see section 2: Fire) or specialist process lighting (see clause 6.5.1 above).

Alternative ways (or a combination of ways) that can be considered as achieving the objectives of the standard for general artificial lighting are:

a. the radial distance on plan from any local switch to any luminaire it controls should generally be not more than 6 metres, or twice the height of the luminaire above the floor if this is greater. Such switches should be readily accessible (e.g. located on circulation routes);

b. switches can be operated by ultrasonic, infra-red or other remote control handsets;
c. if lighting rows are located adjacent to windows, they can be controlled by photocells which monitor daylight and adjust the level of artificial lighting accordingly, either by switching or dimming;
d. automatic switching which turns the lighting on or off when it senses the presence or absence of occupants; or
e. *buildings* used for industrial, retail, assembly, entertainment or other similar uses and in areas where continuous lighting is required by the occupants of the *building* during hours of operation, the control can be by way of time switching or daylight-linked photo-electric switching. For managed spaces in these *buildings* centralised manual switching can be considered. Examples of managed spaces include: cinema/theatre, sports hall, restaurant, passenger terminal, museum/gallery, foyer, large *kitchen* and *shop*.

www.cibse.org

Another way that can be considered as achieving the objectives of the standard for general artificial lighting is to install switching in accordance with the advice and guidance given in the Society of Light and Lighting (CIBSE) Code for Lighting 2002.

Display lighting

When considering energy efficient switching for display lighting, dedicated circuits should be provided, that can be switched off at times when people will not be inspecting exhibits or merchandise or occupying the spaces used for public entertainment. In a retail store, for example, this could be achieved by timers to switch off the display lighting outwith opening hours, or possibly at a later time of the day for displays which are intended to be viewed from outside the *building*.

6.5.4 Work on existing buildings

When a *building* with a floor area of more than $50m^2$ and installed with artificial lighting is altered or extended the general purpose artificial lighting systems should be designed to be energy efficient.

Paragraphs, (a) (b) and (c) below, give three alternative ways of achieving the objectives of the guidance:

a. Where the design has been completed in accordance with the advice and guidance given in the Society of Light and Lighting (CIBSE) Code for Lighting 2002.
b. Where the installed lighting capacity comprises lighting fittings with lamps having an average initial (100 hour) efficacy of not less than 65 lumens per circuit Watt. The lamp lumen output tables are obtainable from the manufacturers' published data.
c. Where 95% of the artificial lighting capacity in circuit Watts (i.e. the power consumed by lamps, their associated control gear and power factor correction equipment) is provided by lighting fittings using lamps with luminous efficacies not less than those of the types listed in the table below:

Artificial lighting

Light Source	Types and ratings
High pressure sodium	All types and ratings
Metal halide	All types and ratings
Induction lighting	All types and ratings
Triphosphor or Multi-phosphor tubular Fluorescent	All 26mm dia. (T8) Lamps, and 16 mm dia. (T5) lamps rated above 11W, fitted with low-loss or high frequency control gear. All 38 mm dia. (T12) linear fluorescent lamps 2400mm long.
Compact fluorescent	All ratings above 11W.
Other	Any type and rating with an efficiency greater than 65 lumens per circuit Watt.

Notes:

1. A worked example of this approach can be found in Annex 6.D – Lighting Calculations.

6.6 Mechanical ventilation and air conditioning (MVAC)

standard

6.6

mandatory

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) in non-domestic *buildings*, the 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

Mechanical ventilation is a primary energy intensive process, and air conditioning is even more so. When considering the installation of mechanical ventilation and air conditioning (MVAC), attention should therefore be given to:

- form and fabric of the *building*;
- energy efficiency of the equipment; and
- control of the equipment.

CIBSE Technical Memorandum 36 (TM36)

Designers may wish to design beyond the current guidance to consider the possible impacts of future global warming on the risks of higher internal temperatures occurring more often. CIBSE Technical Memorandum 36 (TM36) 'Reducing overheating – a designer's guide' gives guidance on this issue.

Natural Ventilation

The designer should consider natural ventilation controls appropriate for the *building* geometry (which could include a combination of B rise Soleil, natural ventilation controls and daylight controls) . Particular attention should be paid to limiting overheating by ensuring that areas of the external *building* fabric which are susceptible to solar gain have appropriate areas of translucent *glazing* and/or solar shading. If a naturally ventilated *building* design can achieve an occupied period temperature of always less than 28 $^{\circ}$ C then the BER can be adjusted to give credit for this (refer clause 6.1.6.). A ventilation strategy that incorporates night cooling and the thermal mass of a *building* should also be considered for effective natural ventilation control.

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).

6.6.1 Form and fabric in relation to MVAC equipment.

The form and fabric of the *building* should not result in a need for excessive installed capacity of mechanical ventilation and cooling equipment.

When considering the proportions of *glazing* in the *building*, the designer should give consideration to the provision of daylight controls and adequate levels of daylight – refer to BS 8206-2: 1992 for guidance on daylighting.

CIBSE Technical Memorandum 37 (TM37)

CIBSE Technical Memorandum 37 (TM37) provides a method for making an assessment of the risks of excessive temperatures occurring.

CIBSE suggest that for office type spaces, the number of occupied hours above 28°C should not exceed 1% of the annual occupied period.

6.6.2 Efficiency of MVAC equipment

Fans (other than individual fans that serve a small number of *rooms* in an otherwise naturally ventilated *building*), pumps, motors, refrigeration equipment and other components should have no more capacity for demand and standby than is needed. They should not be oversized as energy efficiency and power factor values will be adversely affected. Fan characteristics should be matched to the volume control using variable speed motors and variable pitch fans to optimise fan performance at part load.

Where air conditioning systems are installed to provide comfort cooling the minimum energy efficiency ratios of such systems can be demonstrated in the table below.

Comfort cooling energy efficiency ratio

Comfort cooling systems	Required minimum Energy Efficiency Ratio (EER)
Package air conditioners- single *duct* types	1.8
Package air conditioners - other types	2.2
Split and multi-split air conditioners (incl. VRF)	2.4
Vapour compression cycle chillers - water cooled	3.4
Vapour compression cycle chillers - air cooled	2.25
Water loop heat pump	3.2
Absorption chillers	0.5
Gas fired variable refrigerant flow (VRF)	1.0

Where fan systems are installed to either provide ventilation or air circulation, the total specific fan power (SFP) (i.e. the design power of all fans in the distribution system divided by the design ventilation rate through the *building*) should not be greater than 1.5 W/litres/second. The individual specific fan power at the design flow rate should be no worse than the values in the table of air distribution systems below. Ventilation system fans rated at more than 1100 W should be fitted with variable speed drives to ensure they operate efficiently by varying the output of the fan to match the actual demand.

Consideration should be given to allowing greater SFP where specialist processes occur or if the external air is more heavily polluted, as better air filtration or cleaning may be appropriate. Fan characteristics should be matched to the volume control using variable speed motors and variable pitch fans to optimise fan performance at part load.

Air distribution permissible specific fan power

Air distribution systems	Maximum permissible specific fan power (Watts/(Litres/s))
Central mechanical ventilation including heating, cooling and heat recovery.	2.5
Central mechanical ventilation including heating and cooling.	2.0
All other central systems.	1.8
Local ventilation only units remote from the area, such as ceiling void or roof mounted units serving one *room* or area.	0.5
Local ventilation only units within local area, such as window/wall/roof units, serving one *room* or area.	1.2
Other local units, e.g. a fan coil unit.	0.8

6.6.3 Ductwork Installation

HVCA DW/143

To minimise air leakage and energy use, ventilation sheet metal ductwork should be airtight and where *constructed* of sheet metalwork be in accordance with HVCA DW/143 Specification for sheet metal ductwork.

6.6.4 Control of MVAC equipment

Appropriate ways should be provided to manage, control and monitor the operation of the equipment and systems that are installed in the *building*.

Temperature sensors

Temperature sensors should be provided in areas for the services being controlled. The temperature control should be selected for the minimum energy consumption for the given occupancy conditions. The control system of the air conditioning system should be set up to avoid simultaneous heating and cooling and minimise energy consumption.

Free cooling

Free cooling should be optimised in order to minimise the running costs of the mechanical ventilation and air conditioning system. Central air handling units should have damper controls to provide fresh air as the first stage of cooling. When the external air is higher than the space temperature the dampers should be overridden to provide a minimum level of fresh air. Enthaply control should also be considered to improve free cooling.

Night time cooling

Night time cooling to pre-cool the *building* structure overnight should be considered to limit daytime cooling demand and minimise energy consumption.

6.6.5 Work on existing buildings

Where an entirely new or replacement air conditioning system is being installed as part of an alteration, extension or *conversion* refer to the guidance in previous clauses.

If an air conditioning system is being replaced in part, or being extended, the guidance in previous clauses should be followed but only as it affects the new or replaced components of the system. Such alterations should not allow the air conditioning system as a whole to be downgraded in terms of energy efficiency or compromised from a safety point of view.

6.7 Commissioning building services

contents

standard

6.7

mandatory

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 ensuring 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 ensure efficient use, unless they are exempt under schedule 1, regulation 3. Major power plants which serve a number of *buildings* (e.g. an industrial estate) 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

A *building* services installation in a *building* should be inspected and commissioned in accordance with manufacturers' instructions to ensure optimum energy efficiency. The *building* and services should have facilities such as test points, inspection hatches and measuring devices to enable inspection, testing and commissioning to be carried out.

CIBSE/BSRIA

One way that can be considered as following the guidance would be to use the CIBSE Commissioning Codes and BSRIA Commissioning Guides.

6.7.2 Ductwork Leakage Testing

HVCA DW/143

One way that can be considered as following the guidance would be by confirming that the leakage testing has been *constructed* to meet the equivalent leakage performance standards specified in HVCA DW/143: A practical guide to ductwork leakage testing.

6.7.3 Work on existing buildings

Ductwork leakage testing (see above clause) can only be carried out on *ducts* that are completely new and where it is possible to isolate the new *duct* from the existing.

6.8 Written Information

standard 6.8 mandatory	**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, ventilation and cooling 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 appropriate 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 ensure efficient use unless they are exempt under schedule 1, regulation 3. Major power plants which serve a number of *buildings* (e.g. an industrial estate) 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 Logbook information

CIBSE TM31

CIBSE Technical Memorandum 31 (TM31) provides guidance on the presentation of a logbook, and the logbook information should be presented in this or a similar manner.

The logbook should contain information about all aspects of energy system operation and maintenance to ensure that the *building* user can optimise the use of fuel. This should include detailed information on *building* services plant and controls.

6.8.2 Work on existing buildings

It is recognised that some alterations to *building* services, because they are done on a piecemeal basis, will not result in optimum energy efficiency being attained for the entire system. Where this occurs, the person responsible for the commissioning of that part of the system should make available to the owner and *occupier*, a list of recommendations that will improve the overall energy efficiency of the system.

On completion of the extension or alteration to the *building* services system, the commissioning information should be updated in the logbooks.

6.9 Energy performance certificates

standard **6.9** mandatory	**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*, indicating the approximate annual carbon dioxide emissions and energy usage of the *building* based on a standardised use of the *building*;** **(b) the energy performance for the certificate is calculated in accordance with a methodology which is asset-based, conforms with the European Directive 2002/91/EC and uses UK climate data; and** **(c) the energy performance certificate is displayed in a prominent place within the *building*.** **Limitation:** (a) This standard does not apply to *buildings* which do not use fuel or power for controlling the temperature of the internal environment; (b) this standard does not apply to non-domestic *buildings* and *buildings* that are ancillary to a *dwelling* that are *stand alone* having an area less than 50 square metres; (c) this standard does not apply to *conversions*, alterations and extensions to *buildings* other than alterations and extensions to *stand-alone buildings* less than 50 square metres that would increase the area to 50 square metres or more, and alterations to *buildings* involving the fit-out of the *building* shell which is the subject of a continuing requirement; or (d) this standard does not apply to *limited life buildings* which have an intended life of less than 2 years. (e) Standard 6.9(c) only applies to *buildings* with a floor area of more than 1000 square metres, which are occupied by public authorities and institutions providing public services, which can be visited by the public.

6.9.0 Introduction

Article 7 of EU Directive (2002/91/EC) on the energy performance of *buildings* requires energy performance certificates (EPCs) to be made available to prospective owners and tenants when buildings are *constructed*. Standard 6.9 achieves this by making EPCs fixtures within *buildings*.

It is intended that Scottish Ministers will direct local authorities to apply standard 6.9 to all existing *buildings* using Section 25 (2) of Building (Scotland) Act 2003. The direction will limit the description of *building* to which it applies to those that are being sold or rented out and public *buildings* over 1000m^2 floor area. It is proposed that guidance leaflets will be produced 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.

Methodology and calculation tool

The certification should be carried out using the Directive compliant methodology and the calculation tool which was used to assess compliance with standard 6.1. In many cases the SBEM calculation tool will have been used for the new *building*. However, if a detailed simulation model has been used to comply with standard 6.1 it is acceptable to use it to do the energy performance calculation to produce the certificate. Scottish climate data should be used in preference to generic UK data.

Use of actual values
Dwellings

For the purpose of a establishing a rating for the energy performance certificate for a new *building* the values and specifications used to obtain building warrant (as varied by any subsequent amendments to warrant) should be adopted. Where a *building* contains multiple units a rating can be produced for either the whole *building* or for each individual unit. However, if a non-domestic *building*, incorporates within it a *dwelling* (e.g. a caretaker's *flat*) a separate certificate should always be provided for the *dwelling* and reference should be made to the Domestic Technical Handbook.

6.9.2 Information to be provided for buildings

The energy performance certificate should display the following information:

- the postal address of the *building* for which the certificate is issued;
- *building* type;
- the name of the SBSA protocol organisation issuing the certificate (if applicable) and may include the member's membership number;
- the date of the certificate;
- the 'conditioned' floor area of the *building*;
- the main type of heating and fuel;
- the type of electricity generation;
- whether or not there is any form of *building* integrated renewable energy generation;
- the calculation tool used for certification;
- the type of ventilation system;
- a specific indication of current CO_2 emissions and an indication of potential emissions expressed in kg of CO_2 per m^2 of floor area per annum;
- a seven band scale in different colours representing the following bands of carbon dioxide emissions; A, B, C, D, E, F and G, where A = excellent and G = very poor;
- the approximate energy use expressed in kWh per m^2 of floor area per annum;
- a list of cost-effective improvements (lower cost measures);
- a statement to the effect of 'N.B. THIS CERTIFICATE MUST BE AFFIXED TO THE BUILDING AND NOT BE REMOVED UNLESS IT IS REPLACED WITH AN UPDATED VERSION'; and
- a statement to the effect of 'THIS CERTIFICATE SHALL BE DISPLAYED IN A PROMINENT PLACE', if the *building* is a public *building* and over $1000m^2$ in area and is as described in clause below.

www.sbsa.gov.uk

A model form for an energy performance certificate for a *building* is given on the SBSA website.

cost-effective improvement

There are only limited cost-effective, low-cost, energy-efficiency improvements that can be made to the fabric of a new *building* (when no other *work* is proposed) such as upgrade insulation in an accessible *roof space*. However, there are several low cost measures that can be done to the *building* services. Examples are:

- fitting low energy lamps throughout the *building*;
- installing lighting management systems;
- insulating pipe-valves; and
- fitting variable speed motor control for fans and pumps.

Measures presented on the certificate must meet Scottish building regulations, be specific to the individual *building* and be technically feasible.

Additional advice

Certificates may give additional advice on projected 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 on improvements that are either aspirational (e.g. photovoltaics) or enhanced management and control features (e.g. automatic monitoring and targeting with alarms for out of range values). All of this is welcome, but in every case, such information should only be provided as an appendix to the certificate and be accompanied by advice on relevant warrants and building regulations.

6.9.3 Location of an energy performance certificate

Public *buildings* over 1000 m²

Buildings with an area of over 1000 m² occupied by public authorities and by institutions providing public services to a large number of persons and therefore frequently visited by these persons, must have an energy certificate (no more than 10 years old) placed in a prominent place. A suitable location would be an area of wall which is clearly visible to the public in the main entrance lobby or reception.

The public *buildings* referred to in the paragraph above described and characterised by all of the following:

a. the area of the *building* is over 1000 m^2;
b. the *building* is occupied by public authorities or provides public services to a large number of persons;
c. the *building* is frequently visited, at least weekly, by members of the general public;
d. the public have a right of access to the *building* or the parts thereof providing services directly to the public; and
e. public funding, even in part, is used in the operation of the *building*, or in the general upkeep of the *building* or in funding costs of staff employed therein.

Examples of such *buildings* are:

- colleges (further education, higher education), universities;
- community centres;
- concert halls, theatres;
- crematoria;
- day centres;
- education centres, schools (nursery, primary, secondary, special);
- exhibition halls (multi-function centres)
- headquarters' *buildings* (of local authorities such as district councils, health & social services trusts and boards, education and library boards, etc.) where the public have an unqualified right of access (for example to

attend council meetings, parliamentary meetings or other events to which the public have access);
- health centres, *hospitals*;
- hostels, halls of residence;
- law courts;
- leisure centres, swimming pools, sports pavilions;
- libraries, museums, art galleries;
- *offices* (passport *office*, motor tax *office*, benefits *office*, etc.) having a public counter and providing services directly to the public;
- outdoor centres;
- passenger terminals (rail, bus, sea, and air);
- police stations (with a public counter);
- residential care *buildings*;
- visitor centres; and
- youth centres.

The above list is not comprehensive, but indicates the type of *buildings* which should display an energy performance certificate.

Other *building* types

For all other *buildings*, 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. Any appendix giving additional information should be removed if space is limited and it will obstruct the energy performance certificate.

6.9.4 Small stand-alone buildings

For *stand alone* ancillary *buildings* of less than $50m^2$ floor area, an energy performance certificate need not be provided. Examples are, in the case of the former, a kiosk for a petrol filling station which is associated with a supermarket and for the latter, one or two *offices* and a *toilet* located in an otherwise unheated warehouse. For stand-alone *buildings* of a floor area of $50\ m^2$ or more that are heated or cooled which are ancillary or subsidiary to the main *building*, a certificate should be provided, in addition to the one for the main *building*.

6.10 Metering

standard

6.10

mandatory

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

Limitation:

This standard does not apply to:

(a) domestic buildings;

(b) communal areas of buildings in *different occupation*;

(c) district or block heating systems where each part of the *building* designed for *different occupation* is fitted with heat meters; or

(d) heating fired by solid fuel or biomass.

6.10.0 Introduction

To enable *building* operators to effectively manage fuel use, systems should be provided with fuel meters to enable the annual fuel consumption to be accurately measured.

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).

6.10.1 Metering

All buildings should be installed with fuel consumption metering in an accessible location, such as presently installed by the utility.

Each area divided by separating walls and separating floors and designed for *different occupation* should be provided with a fuel meter to measure the fuel usage in each area.

Multiple buildings

Where multiple buildings or fire separated units are served on a *site* by a communal heating appliance, the fuel metering shall be installed both at the communal heating appliance and heat meters at the individual buildings served.

Combined heat and power

Metering shall be provided to measure the hours run, electricity generated, and the fuel supplied to a combined heat and power unit.

6.10.2 Metering in existing buildings

Existing *buildings* which are a result of a *conversion* or in *buildings* where an extension or alteration is carried out should be installed with fuel consumption metering. The guidance in the above clause is applicable to this clause.

Where conversions, extensions or alterations, result in the creation of 2 or more units, each unit should have a fuel meter installed in an accessible location.

A fuel meter should be installed if a new fuel type or new boiler (where none existed previously) is installed.

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

contents

annex 6.A

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 standard 6.2. It may be used in the following cases;

a. where it is not possible to input the individual *U-values* for all the windows, doors and rooflights for the proposed new *building* into the calculation methodology;
b. for work to existing non-domestic *buildings*, namely, replacements, alterations, extensions, and *conversions* (standard 6.2); and
c. for small *stand-alone buildings* such as one or two *offices* and a *toilet* located in an otherwise unheated warehouse.

Individual windows, doors or rooflights may have *U-values* that exceed the *U-values* in the guidance to standard 6.2 provided that the average *U-value* for all the windows, doors and rooflights is not exceeded.

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

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

A *building* has a total window area of 16.9 m^2 (including frames) and a total door area of 3.8 m^2. It is proposed to use two external quality timber finished 'fire' doors with a *U-value* of 2.0 W/m^2K. In order to follow the guidance to standards 6.1 and 6.2, the additional heat loss due to the use of the 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 1.8 W/m^2K.

U-value calculation

Element	Area (m²)	U-value (W/m²K)	Rate of heat loss per degree (W/K)
Windows	16.9	1.7 [1]	28.73
Doors	3.8	2.0	7.6
Rooflights	0.9	1.9 [1]	1.71
Total	21.6		**38.04**

Notes:

1. These *U-values* correspond to double-glazed windows or rooflights with a wood or plastic frame, with a 16 mm argon-filled space between the panes and a soft low-emissivity coating on the glass.

This gives an average *U-value* of 38.04 ÷ 21.6, or 1.76 W/m^2K, which is below 1.8 W/m^2K. The windows, doors and rooflights can therefore be considered to follow the objectives for the *insulation envelope* to reduce heat-loss.

Annex 6.B Compensatory approach - heat loss example

contents

annex 6.B

6.B.0 Introduction

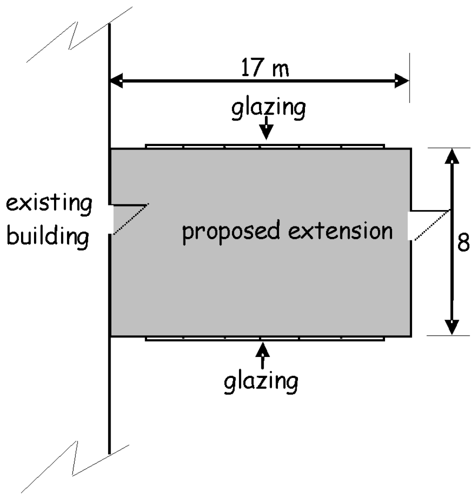
This annex gives an example of the compensatory approach for use with an extension. This is likely to be of use where there is a need to specify one or more *constructions* with a *U-value* better than the recommended maximum area weighted average *U-values* given in column (a) of the table to clause 6.2.10, although the example given in this instance is for an extension, the same principles are relevant to a *conversion* to which 6.2.7 applies and substantial alterations.

6.B.1 Extension to an existing building

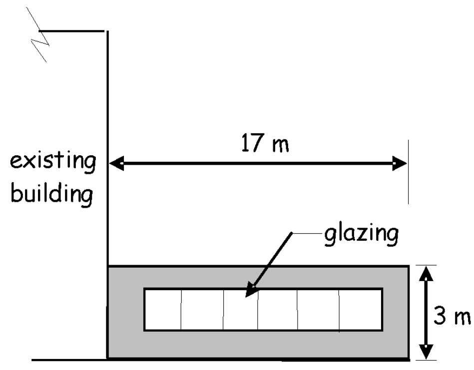
First the internal exposed surface areas of all the elements with different area weighted *U-values* are calculated. Then the heat loss for the proposed development is calculated. One or more *U-values* may be higher or lower than those recommended in column (a) of the table to clause 6.2.10 and the percentage windows and doors area as proposed may be less or equal than the maximum percentage area of the exposed wall area (given in clause 6.2.10). After that the heat loss for a 'notional' extension (i.e. a *building* the same size and shape as the proposed and with its area window and doors) is calculated using *U-values* in the table to clause 6.2.10. The heat loss calculated for the proposed *building* should be less than or equal to that for the 'notional' one.

Compensatory approach example

It is proposed to form a 3 m high extension onto an existing single *storey office building*. The extra floor area created will be 136 m^2. A plan of the proposed layout is shown in the figure below. In this example the principle compensatory measure is the omission of rooflights, as the designer considers that it is easier to provide solar shading to slightly larger windows. The existing *building* and extension will be heated to a similar degree so there is no heat loss considered between these 2 areas.



Plan



Elevation

6.B.2 Proposed extension

From the information in 6.B.1 the rate of heat loss from the proposed extension is calculated as follows;

Proposed extension heat loss calculation

Exposed Element	Exposed surface area (m^2)	U-value (W/m^2K)	Rate of heat loss (W/K)
External Wall	126-63 = 63	x 0.25 =	15.75
Roof	136.0	x 0.21 =	28.56
Floor	136.0	x 0.25 =	34.00
External Door	3.0	x 1.8 =	5.4
Window	2 of (15x2m) = 60.0	x 2.0 =	120
Rooflight	Not applicable		
Total rate of heat loss		**=**	**203.71**

6.B.3 'Notional extension'

The rate of heat loss from the notional extension is then calculated as follows;

Notional extension heat loss calculation

Exposed Element	Exposed surface area (m^2)	U-value ($W/m^2 K$)	Rate of heat loss (W/K)
External Wall	126 - 50.4 = 75.6	x 0.27 =	20.41
Roof	136 - 27.2	x 0.20 =	21.76
Floor	136	x 0.22 =	29.92
Window + Ext. Door	50.4 (40%)	x 1.8 =	90.72
Rooflight	27.2	x 1.8 =	48.96
Total rate of heat loss		**=**	**211.77**

6.B.4 The comparison

The rate of heat loss from the proposed extension is less than that from the ‘notional extension’ and therefore the design of the development has followed the guidance to clause 6.2.10.

Annex
6.C Energy performance of modular and portable buildings

contents

annex 6.C

6.C.0 Introduction

Modular and portable *buildings* are prefabricated *buildings* which are designed for delivery to site as sub assemblies, connected together and completed on site. These *buildings* can be disassembled into their sub-assemblies when no longer required and transported to another location and reassembled.

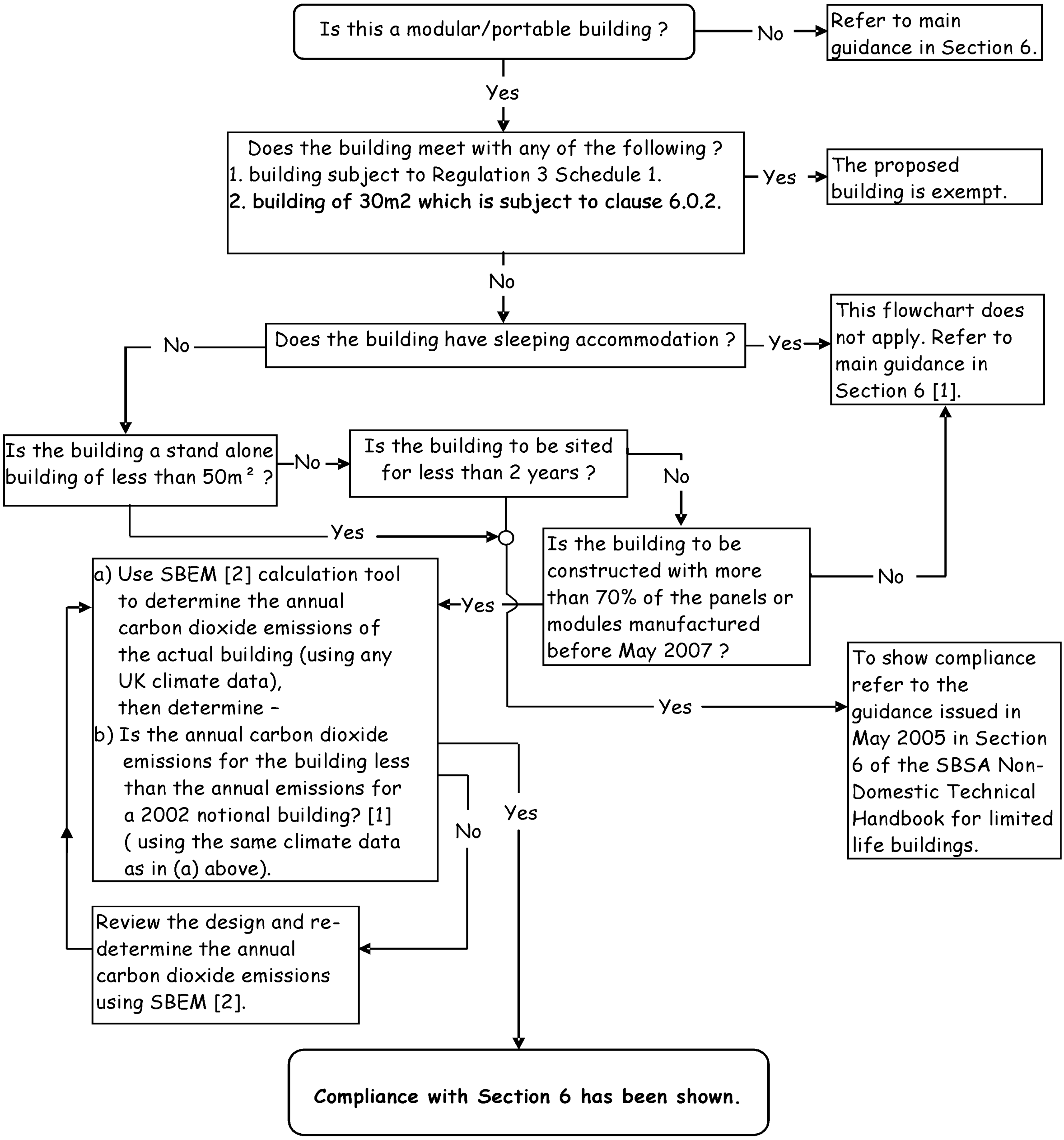
Sub-assemblies are clearly identifiable elements manufactured from a number of components but not the components or raw materials themselves. They can be single or multiple volumetric modules or flat pack modules.

This annex provides guidance on the concessions given to modular and portable *buildings* where;

- a *building* with more than 70% of its external envelope is to be created from sub-assemblies which are manufactured before 6 April 2006 and which are obtained from a centrally held stock or from the disassembly of *buildings* on other premises; or
- the intended life of a *building* is less than 2 years.

6.C.1 Flow Chart to show compliance with section 6

The following flowchart gives guidance on the possible compliance routes. There are no concessions for *limited life buildings* which are *constructed* in a conventional manner.



Note

1. There is no manufacturing capability for modular and portable buildings in Scotland, the 2002 notional building is therefore the same as the 2002 notional building in England and Wales.
2. It may be appropriate to use an alternative calculation tool, see clause 6.1.1

Annex 6.D Lighting Calculations

annex 6.D

6.D.0 Introduction

This annex shows 2 ways of providing energy efficient lighting to work on existing *buildings*. With the move to a methodology based approach using the SBEM calculation tool, these examples are not applicable to new *buildings*.

6.D.1 Examples

Example (a) is for an extension to an existing *building* and example (b) is for a complete replacement of a lighting scheme. These approaches are not however exclusive to the type of work referred to in this annex, i.e. the first example could be adopted for new *build* and the second, for an extension. Where the *work* consists of an alteration or replacement these methods can be used, but only where a completely new system of lighting is to be provided.

Tables (a) and (b) below show a schedule of the lighting sources proposed. Lighting calculation show that 95% of installed circuit power is comprised of lamps listed in the tables.

Example (a).

A new hall and changing rooms are to be added to an existing community centre. The proposed lighting scheme incorporates lamps that are listed in the table to clause 6.5.1 a. except for some low voltage tungsten halogen down-lighters which are to be installed in the entrance area with local controls. A check therefore has to be made to show that the low voltage tungsten halogen lamps comprise less than 5% of the overall installed capacity of the lighting installation.

Main hall specification

Twenty wall mounted up-lighters with 250 W high pressure sodium lamps are to provide general lighting needs. The up-lighters are to be mounted 7 m above the floor. On plan, the furthest light is 20.5 m from its switch, which is less than three times the height of the light above the floor. It is also proposed to provide twenty, 18 W compact fluorescent lights as an additional system enabling instant background lighting whenever needed.

Specification for changing rooms, corridors and entrance

Ten 58 W, high frequency fluorescent light fittings are to be provided in the changing rooms and controlled by occupancy detectors. Six more 58 W fluorescent light fittings are to be located in the corridors and the entrance areas and switched locally. Additionally, in the entrance area there are to be the six 50 W tungsten halogen down-lighters noted above.

Lighting schedule

Position	Number	Description of light source	Circuit Watts per lamp	Total circuit Watts (W)
Main hall	20	250 W SON	286 W	5720
Main hall	20	18 W compact fluorescent	23 W	460
Changing *rooms* and corridors	16	58 W HF fluorescent	64 W	1024
Entrance	6	50 W low voltage tungsten halogen	55 W	330

From the schedule of light fittings above, the total circuit Watts of the lamps in the installation is 7534 W.

The percentage of circuit Watts consumed by lamps not listed in the table to clause 6.5.1a: = 330 ÷ 7534 X 100 = 4.4%

Therefore, more than 95% of the installed lighting capacity, in circuit Watts, is from light sources listed in the table to clause 6.5.4. The switching arrangements follow the guidance in clause 6.5.3. The lighting scheme can therefore be considered as following the guidance in section 6.

Example (b)

A lighting scheme is proposed for a public house extension comprising a mixture of concealed perimeter lighting using high frequency fluorescent fittings and supplementary compact fluorescent lamps in the dining area. Lights in the dining and lounge areas are to be switched locally from behind the bar. Lighting to *kitchens* and *toilets* is to be switched locally.

Lighting schedule

Position	Number	Description	Circuit Watts (W) per lamp	Lumen output (lm) per lamp	Total circuit Watts (W)	Total lamp lumen output (lm)
Over tables	20	11 W compact fluorescent	16	900	320	18,000
Concealed perimeter and bar lighting	24	32 W T8 fluorescent high frequency ballast	36	3300	864	79,200
Toilets and circulation	6	18 W compact fluorescent with mains frequency ballast	23	1200	138	7,200
Kitchens	6	50 W, 1500 T8 fluorescent with high frequency ballast	56	5200	336	31,200
				Totals	1658	135,600

From the schedule of light fittings above, the total lumen output of the lamps in the installation is 135,600 lumens.

The total circuit Watts of the installation is 1658 Watts.

Therefore, the average circuit efficacy is:

= 135,600/1658 = 81.8 Lumens/Watt

The proposed lighting scheme can be considered as following the guidance in section 6.

Note that if 60W tungsten lamps were used in the dining area instead of the 11W compact fluorescent lamps actually proposed, the average circuit efficacy would drop to 51.9 lumens/W, which would not be following the guidance in clause 6.5.4.

Annex 6.E Determining seasonal boiler efficiency

contents

annex 6.E

6.E.0 Introduction

This annex shows a way of determining seasonal boiler efficiency and supports the guidance to standard 6.3. The guidance given here applies to commercial boilers for use in wet central heating systems as follows:

- natural gas boilers;
- liquid petroleum gas (LPG) boilers; and
- oil-firing boilers.

6.E.1 Single boiler systems and multiple-boiler systems using identical boilers

The seasonal boiler efficiency is a ‘weighted’ average of the efficiencies of the boiler at 15%, 30% and 100% of the boiler output This is usually quoted by the boiler manufacturer. Note that the efficiency based on net calorific value should be converted to that based on gross calorific value using the appropriate conversion factors below.

Fuel type conversion factors

Fuel Type	Conversion Factor
Natural Gas	0.901
LPG	0.921
Oil	0.937

To convert from net efficiency to gross, multiply the factor by the appropriate fuel. e.g. for a LPG boiler at 80% net x 0.921 = 73.68% net.

The boiler efficiencies, measured at 100% load and at 30%, are used as the basis for calculating the seasonal boiler efficiency as described by equation 1 below. The weighting factors given in equation 1 should be used as they represent typical seasonal operating conditions for the boiler.

Equation 1 applies in the following conditions:

- single boiler systems where the boiler output is not more than 400kW and the boiler will operate on a low temperature system;
- multiple-boiler systems where all individual boilers have identical efficiencies and where the output of each boiler is not more than 400 kW operating on low temperature systems. For boilers with an output greater than 400 kW the manufacturer’s declared efficiencies should be used.

Equation 1

$$\text{Seasonal boiler efficiency} = 0.81\eta 30\% + 0.19\eta 100\%$$

Where the terms in Equation 1 are defined as follows;

- $\eta 30\%$ is the gross boiler efficiency measured at 30% load;
- $\eta 100\%$ is the gross boiler efficiency measured at 100% load;

Equation 1 assumes that the efficiency at 15% load is taken to be the same as that at 30% (and therefore the equation has been simplified accordingly).

6.E.2 Multiple-boiler system replacing an existing installation where the component boilers have non-identical efficiencies

Where more than one boiler is installed on the same heating system and the efficiencies of the boilers are not all identical, equation 2 should be used to calculate the overall seasonal boiler efficiency. All boilers should be included in the calculation, even when some are identical.

Seasonal boiler efficiency for a multiple-boiler system replacing an existing installation where the component boilers have non-identical efficiencies where more than one boiler is installed on the same heating system and the efficiencies of the boilers are not all identical than equation 2 should be used to calculate the overall seasonal boiler efficiency. All boilers should be included in the calculation, even when some are identical.

Seasonal boiler efficiency (multiple-boiler systems with non-identical boilers)

Equation 2

$\eta osbe = \eta sbe.R \ \Sigma \ R$

Where the terms in Equation 2 are defined as follows:

- ηosbe is the gross overall seasonal boiler efficiency, being a weighted average with respect to boiler output, of the individual seasonal boiler efficiencies
- ηsbe is the gross seasonal boiler efficiency of each individual boiler calculated using equation 1
- R is the rated output in kW of each individual boiler (at 80ºC/60ºC).

6.E.3 Multi-boiler system in a new building

DCLG Compliance Guide

In the case of multiple boilers in a new *building*, the more accurate three-step method described below should be used to calculate the overall seasonal boiler efficiency for multiple-boilers. This can be used to follow through the following calculations. The following worksheet (taken from DCLG Non Domestic Heating, Cooling and Ventilation Compliance Guide) shows a completed example calculation using this worksheet. The following calculation can be used to demonstrate the overall seasonal boiler efficiency of a multiple-boiler system.

Step 1

Determine which boilers are operating at what individual part load level at each of the three system part load conditions of 15%, 30% and 100%. For example, if the total system output is made up of three equally sized boilers, at 15% of system output, the lead boiler will be operating at 45% of its rated output, with the other two boilers switched off.

Step 2

Determine the efficiency at which each individual boiler is operating at each of the above operating conditions. In the above example, the efficiency of the boiler operating at 45% can be determined by linear interpolation between its efficiencies at 30% and 100% of rated output. Where it is necessary to determine the efficiency of an individual boiler at 15% of rated output, this should be taken as the same as the efficiency at 30% of rated output. (Note that the efficiency at 15% of rated output will only be needed if a single boiler meets the full design output.)

Step 3

Calculate the overall operating efficiency at each of the system part load conditions. This is calculated using equation 3:

Equation 3

$\eta_p = Qp \ / \ (\Sigma \ qb,p \ / \ \eta b,p)$

where η_p = the system efficiency at part load condition p, i.e. 15%, 30% and 100% of system rated output.

Qp = the system heat output at part load condition p.

qb,p = the individual boiler heat output at system part load condition p.

η b,p = the individual boiler efficiency at system part load condition p.

Calculate the overall seasonal boiler efficiency as the weighted average of the efficiencies at the three load conditions using equation 4:

Equation 4

η OSBE = $0.36\eta p{=}15\% + 0.45\eta p{=}30\% = 30\% + 0.19\eta p{=}30\%$

The following worksheet shows a completed example of calculating the overall seasonal boiler efficiency of a multi-boiler system.

Overall seasonal boiler efficiency worksheet

Boiler No.	Rating kW	Efficiency at stated % of boiler output		Boiler output at stated % of system output			Boiler efficiency at stated % of system output		
		100%	30%	15%	30%	100%	15%	30%	100%
1	250.0	86.0	90.0	36.0	72.0	100.0	89.66 [1]	87.6	86.0
2	250.0	86.0	90.0	0.0	0.0	100.0	90.0	90.0	86.0
3	250.0	85.0	90.0	0.0	0.0	40.0	77.0	77.0	85.0
System efficiency at part load							89.66	87.60	85.41 [2]
Weighting factor							0.36	0.45	0.19
Overall seasonal boiler efficiency							**87.28%** [3]		

Notes:

1. Calculated by linear interpolation. η= n30% + (η30% - η100%) x (36%-30%) ÷ (100%-30%).
2. Calculated by dividing the thermal output of the system (600kW) by the rate of fuel consumption, which is given by the sum of the boiler outputs divided by their individual operating efficiency, i.e. 600 ÷ [(250 x 100%/86%)+(250 x 100%/86%)+(250 x 40%/85%)] = 85.41%
3. Calculated as the weighted average, formulae to be confirmed. i.e. (86.66% x 0.36)+(87.6% x 0.45)+(85.41% x 0.19) = 87.92%

Annex
6.F Heating Efficiency Credits

annex 6.F

6.F.0 Introduction

This annex shows how heating efficiency credits can be used for installations in new and existing *buildings*. This annex supports the guidance to Standard 6.3.

- boiler replacements;
- heat-pump systems;
- warm air heaters;
- radiant heater systems; and
- DHW systems.

6.F.1 Boiler replacement in existing buildings

The following tables indicate the range of additional credits which may be used where the boiler seasonal efficiency is less than the minimum effective heat generating seasonal efficiency stated in clause 6.3.2.

Heating Efficiency Credits for boiler replacement.

Ref	Measure	Heating efficiency credits % points	Comments/explaination of terms
A	Boiler oversized by 20% or less.	2	Boiler oversize is defined as the amount by which the maximum boiler heat output exceeds heat output of the system at design conditions, expressed as a percentage of the system heat output. For multiple boiler systems the maximum boiler heat output is the sum of the maximum outputs of all the boilers in the system.
B	Multiple boilers.	1	Where more than one boiler is used to meet the heat load.
C	Sequential control of multiple-boiler systems.	1	Applies only to multi-boiler/module arrangements. It is recommended that the most efficient boiler(s) should act as the lead in a multi-boiler system.
D	Monitoring and targeting.	1	Means of identifying changes in operation or onset of faults. The credit can only be claimed if metering is included and a scheme for data collection is provided for inspection.
E	(1) TRV alone. Also applies to fanned convector systems.	1	TRV's allow relatively close control of building temperature and therefore reduce waste of energy.
	(2) Weather (inside/outside temperature) compensation system using a mixing valve.	1.5	Provides more accurate predication of load and hence control
	(3) Addition of TRV or temperature zone control to (2) above to ensure building temperature control.	1	This credit is additional to E (2) above.
F	(1) A room thermostat or sensor that controls boiler water temperature in relation to heat load.	0.5	
	(2) Weather (inside/outside temperature) compensation system that is direct acting.	2	Provides more accurate prediction of load and hence control.
	(3) Add TRV or temperature zone control to (1) or (2) above to ensure full building temperature control.	1	This credit is additional to F(1) or F(2) above. Note F(1) and F(2) are not used together.

Heating Efficiency Credits for boiler replacement (Cont).

Ref	Measure	Heating efficiency credits % points	Comments/explanation of terms
G	1. Optimised start.	1.5	A control system which starts plant operation at the latest time possible to achieve specified conditions at the start of the occupancy period.
	2. Optimised stop.	0.5	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.
	3. Optimised start/stop.	2	A control system which starts plant operation at the latest time possible to achieve specified conditions at the start of the occupancy period and stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period. Note that if optimised start/stop systems are installed credits G (1.) and G (2.) cannot also be claimed.
H	Full zoned time control.	1	Allowing each zone to operate independently in terms of start/stop time. Only applicable where operational conditions change in different zones. This does not include local temperature control.
I	Full building management system (BMS).	4	A full BMS will allow control, with respect to the heating plant, of the following: the sequential control of multiple boilers, full zoned time controls and weather compensation where applicable; frost protection and/or night set-back; and optimisation and monitoring and targeting. N.B. if a full BMS is installed, where credits are available for the individual components of a full BMS, the credits for the components can not be claimed in addition to these 4 percentage points. So, for example where a full BMS was installed that allowed sequential control of multiple boilers, credit C could not be claimed in addition to credit I.
J	Decentralised heating systems.	1	Elimination of long pipe runs between *buildings* or through unheated areas in existing systems in order to reduce excessive heat losses.

The following example demonstrates using heating efficiency credits to achieve the minimum effective heat generating seasonal efficiency for a boiler replacement.

An existing boiler will be replaced with a gas boiler with a seasonal efficiency of 80%.

To achieve the minimum effective heat generating seasonal efficiency of at least 84%, additional measures, with associated heating efficiency credits, must be adopted.

The following approach would achieve this:

- a decision has been made to restrict oversizing to 15% (after a detailed assessment of load).
- two equally sized boilers will be used to meet the heat load in place of the existing single boiler.
- TRVs will be fitted to control the temperature in areas other than where the room thermostat is fitted.
- the boilers will be fired by natural gas.

The calculation below shows how credits would be awarded in this example. No credit shall be given for the minimum controls package.

Example of Heating Efficiency Credits.

Plant description	**Heating efficiency credits (% points)**
Boiler oversizing is less than 20%.	2
System controlled by room thermostat which controls boiler water temperature.	0.5
System uses TRVs to ensure full building temperature control.	1
Multiple boilers.	1
Total credits.	4.5

For a 80% efficient boiler the effective heat generating seasonal efficiency = (boiler seasonal efficiency) + total heating efficiency credits = 80% + 4.5% = 84.5%

In this example the minimum effective heat-generating seasonal efficiency of 84% given in clause 6.3.2 is exceeded by 0.5%.

6.F.2 Heating efficiency credits for heat pump in new and existing buildings.

Heating efficiency credits are available for measures over and above the minimum level which can be added to the CoP. Where the efficiency measures outlined in clause 6.3.1 table 3 are adopted the relevant efficiency credit (percentage points) can be added to the minimum CoP (or to the manufacturer’s rating, where this exceeds the minimum COP) in order to calculate the effective CoP. An example where this may be used would be to assist in meeting the guidance given in clause 6.2.9 *conversions* of historic *buildings*.

Effective CoP = Coefficient of performance (%) + Total heating efficiency Credits. No credit shall be given for the minimum controls package.

Heating Efficiency Credits

Measure	Heating efficiency credit		Comment
	Ratio	% Points	
less than 20% oversizing	0.02	2	The amount by which the maximum heat pump output exceeds heat output of the system at design conditions, (expressed as a percentage of the system heat output).
Optimised stop	0.02	2	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.
Full zone control	0.02	2	Allowing each zone to operate independently in terms of start/stop time. Only applicable where operational conditions change in different zones.

The following example illustrates how heating efficiency credits can be added to the efficiency of the system to exceed the minimum level.

The proposed building will have an air-to-water, electrically driven heat pump to be used with an underfloor heating system. When tested to EN 14511 the CoP was measured as 2.0 (200%). The following controls packages should be installed:

controls package A (zone control, demand control and time control); and

controls package B which should include the following;

- control of water pump operation and water temperature for the distribution system;
- control of outdoor fan operation for air to water units;
- defrost control of external airside heat exchanger for air to water systems; and
- a room thermostat to regulate the space temperature and interlocked with the HP unit operation.

In addition optimised stop control and full zone control will be installed. The table below shows how credits will be awarded.

Example of Heating Efficiency Credits.

Measure	Heat Plant Efficiency Credit (expressed as a ratio)
CoP	2.00
Optimised stop	0.02
Full zone control	0.02
Total credits	0.04

A single duct air-to-water heat pump with a CoP of 2.0 (in this example manufacturer's rating) will have a effective CoP = (CoP) + (Total heating efficiency credits) = 2.0 + 0.04 = 2.04, The effective CoP would therefore be 2.04, exceeding the minimum CoP given in clause 6.3.2.

6.F.3 Warm air heaters in new and existing buildings

Heating efficiency credits are available for measures listed in the table below. If these measures are adopted, the associated efficiency benefits can be added to the heat generating seasonal efficiency and inputted into SBEM calculation tool or detailed simulation model in order to improve the energy performance rating for the proposed *building*. No credit shall be given for the minimum controls package.

Heating Efficiency Credits for warm air heater installations

Measure	Heating Efficiency Credits (% points)	Comment
Optimised shut down	1	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period
High/Low burners	2	Two stage burners which enable two distinct firing rates
Modulating burners	3	Burner controls allow continuous adjustment between firing rates

It is recognised that destratification fans and air-induction schemes may improve the efficiency of a warm air system and significantly reduce the carbon emissions associated with the heating system. The benefits associated with these measures are calculated in the SBEM calculation tool. Note that warm air systems with air induction schemes or destratification fans should not be confused with central heating with air distribution. Warm air central heating systems are not within the scope of this guidance.

The following example demonstrates using heating efficiency credits to exceed the minimum heat generator seasonal efficiency for a warm air heater.

The proposed *building* will have a gas-fired forced convection warm air heater without a fan to assist transportation of combustion air and/or combustion products. When tested to BS EN 621: 1998 the efficiency is calculated as 80% which meets the minimum heat generator efficiency for this type of system.

The minimum controls package will be installed, i.e. zone, space temperature and time controls. In addition to the minimum controls installed, optimised start/stop and modulating burners will be provided.

Example of Heating Efficiency Credits.

Measure	Heating efficiency credits(% points)
Zone, space and temperature controls	0 (as minimum level)
Modulating burners	3
Optimised shut down	1
Total credits	4

A 80% efficient warm heater will have a effective heat generating seasonal efficiency = gross thermal efficiency + total heating efficiency credits = 80% + 4% = 84%.

Destratification fans will be also be installed providing 7 volume changes per hour. Note that the efficiency benefits of the destratification measures are calculated in the SBEM calculation tool.

The Effective Heat Generating Seasonal Efficiency would therefore be 84%, exceeding the minimum given in clause 6.3.2 by 4%. The value that would be entered in the SBEM calculation tool to calculate an energy performance rating is 84%, expressed as a ratio (i.e. 0.84).

6.F.4 Radiant heaters in new and existing buildings

Heating efficiency credits are available for measures listed in tables below. If these measures are adopted, the associated efficiency benefits can be added to the heat generating seasonal efficiency and input into the SBEM calculation tool in order to improve the energy performance rating for the proposed *building*.

Therefore, when demonstrating compliance for new *buildings* the relevant efficiency value to input into SBEM is the applicable thermal efficiency value in the table given in clause 6.3.1 (or the manufacturer's rating for the appliance being specified, where it exceeds the relevant value in this table) plus any heating efficiency credits.

It is recognised that the efficiency of a heating system using radiant heaters improves with increasing room height. These efficiency benefits arise from a reduction in the ventilation and fabric losses. The efficiency benefits are assigned in the SBEM calculation tool.

Heating Efficiency Credits for radiant heater installations

Measure		Heating efficiency credits (% points)	Comments
Controls (additional to the minimum package)	Optimised shut down	1	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period
	Zone control	1	Allowing each zone to operate independently in terms of start/stop time. Only applicable where operational conditions change in different zones

The following example demonstrates using heating efficiency credits to exceed the minimum heat generator seasonal efficiency for radiant panels.

The proposed *building* will have a *flued* non-luminous radiant heater system with a gross thermal efficiency of 73.8%. A black bulb sensor and an optimiser will be fitted.

The heating efficiency credits associated with these measures in the table below may be added to the appliance thermal efficiency in order to achieve an effective heat generating seasonal efficiency which exceeds the minimum level. The table below shows how credits would be awarded for this example. No credit shall be given for the minimum controls package.

Example of Heating Efficiency Credits.

Measure	Heating efficiency credits (% points)
Black bulb sensor	0
Optimised shut down	1
Zone control	1
Total credits	2

For a radiant heater installation with a gross thermal efficiency of 73%, the heat generating seasonal efficiency is calculated as follows : effective heat generating seasonal efficiency = gross thermal efficiency (73.8%) + total heating efficiency credits (2%) = 75.8%

In this example, the radiant heater system exceeds the minimum thermal efficiency for a thermal efficiency of 73.8% (refer clause 6.3.2). The value that would be entered in the SBEM calculation tool to calculate an energy performance rating is 75.8% – this value should be expressed as a ratio (i.e. 0.758).

6.F.5 DHW systems in new and existing buildings

Heating efficiency credits are available for domestic hot water systems. If these measures are adopted, the associated efficiency benefits can be added to the heat generating seasonal efficiency and entered into the SBEM calculation tool in order to improve the energy performance rating for the proposed *building*. This is shown in the following calculation.

Effective heat generating seasonal efficiency = Heat generator seasonal efficiency + Total heating efficiency credits

where the Heat generator seasonal efficiency is;

- the applicable thermal efficiency value for direct fired systems (or the manufacturer's rating for the appliance being specified, where it exceeds the minimum provisions); or
- The Seasonal boiler efficiency for indirect gas- or oil-fired systems (or the manufacturer's rating for the appliance being specified, where it exceeds the minimum provisions).
- Note that Heating efficiency credits are not available for the minimum controls package.

Heating Efficiency Credits for DHW systems

System Type	Measure	Heating efficiency credits (% points)
All system types	Decentralisation	2 [1]
Direct fired	Integral combustion circuit shut-off device	1
	Fully automatic ignition controls	0.5
All system types	Confirming correct size of unit by using manufacturer's technical help lines and using manufacturer's sizing software	2

Notes:

1. Not applicable to systems in new *buildings.*

Step 1

The following example demonstrates using heating efficiency credits to exceed the minimum heat generator seasonal efficiency for DHW systems.

- recovery rate of heater = 0.4694 litres/second
- gross input rate of heater = 128kW
- specific heat capacity of water = 4.187kJ/kgºC
- temperature rise of water inside heater = 50ºC

The heater output is calculated from: Output of the heater = recovery rate of heater in litres/second x specific heat capacity of water x temperature rise of the water.

0.4694 x 4.187 x 50 = 96.26kW output

The gross thermal efficiency = Output of the heater divided by the gross input.

96.26 / 128 = 0.76%

Step 2

The following table illustrates how the credits would be assigned. No credit shall be given for the minimum controls package.

The heating has been sized to closely match the system demand by using the manufacturer's sizing guide and it will be fitted with fully automatic controls.

Example of Heating Efficiency Credits.

Measure	**Heating Efficiency Credit (% points)**
Sized according to manufacturer's guidance	2
Fully automatic ignition controls	0.5
Total credits	**2.5**

Heat generating seasonal efficiency = gross thermal efficiency + total heating efficiency credits. Therefore the effective heat generating seasonal efficiency should be 76 + 2.5 = 78.5

For this example, the value that would be entered in the SBEM calculation tool is 78.5% expressed as a ratio (i.e. 0.785).