National Calculation Methodology (NCM) modelling guide (for buildings other than dwellings in England and Wales)

2010 Edition

October 2016

Main Changes in the 2010 Edition

This NCM Modelling Guide comes into force on 1 October 2010 in support of the Building and Approved Inspectors (Amendment) Regulations 2010, SI 2010 No.719. The main changes in the technical requirements of software since the issue of the previous NCM Modelling Guide are as follows:

1. New specification of the Notional building for the 2010 edition, which has improved building fabric and HVAC system efficiencies, as well as revised opening areas.
2. Introduction of side-lit, roof-lit, and no-lit glazing class for the Notional building that is determined by the activity type assigned to each zone in the Actual building. The following examples should help to illustrate this:
    a. If a zone is assigned to an office activity (which is classed as side-lit), then in the Notional building that zone will only have windows.
    b. If a zone is assigned to a warehouse activity (which is classed as roof-lit), then in the Notional building that zone will only have rooflights.
    c. If a zone is assigned to a plant room activity (which is classed as no-lit), then in the Notional building that zone will have no windows or rooflights.
3. Revised default Psi values for the Actual building, and the introduction of degradation of non-accredited user-input Psi values as detailed in ADL2A.
4. The heating fuel and heat generator seasonal efficiency in the Notional building both vary as a function of the fuel used for heating in the Actual building, and are determined independently at zone level. This removes the need to define the "main heating fuel" for the Actual building.
5. Auxiliary energy calculation revised for both the Notional and Actual buildings
6. The general lighting in the Notional building is based on 55 luminaire lumens per circuit-watt, with the resulting power density varying as a function of the activity and geometry of each zone.
7. The 2010 target emission rate is the 2010 Notional building emission rate (i.e. no additional improvement factors).
8. Addition of the new criterion 3: limiting solar gains - where the solar gain (aggregated from April to September) for any zone that is either occupied or receives mechanical cooling is checked against a benchmark value.
9. Addition of how "shell & core" buildings should be considered for Building Regulations compliance.
10. Addition of references to ADL2A on the consideration of portable and modular buildings with a planned time of use of more than two years.
11. Addition of new demand control methodology.
12. For the 2010 updates, a revised NCM activity database will be used.
13. A new set of fuel emission factors are provided in this document that are taken from data published in 2010 to revise the emission factors which were originally published in March 2009 within *STP09/CO201: Revised emission factors for the National Calculation Methodologies* (available from www.bre.co.uk/sap2009).
14. November 2011: Addition of guidance regarding lighting systems in warehouse buildings and clarifications regarding racking.
15. December 2012: Modifications to the specification of the zones in the Notional building which use metal-clad constructions (paragraph 27) and to the Notional building's Psi values for thermal bridge junctions with metal-clad constructions (Table 2). Modifications to the

infiltration rate in the Notional building's zones which use metal-clad constructions in the case of buildings with small total areas (paragraph 35). Various clarifications to existing text.

16. January 2013: Modifications to implement the requirements of the EPBD Recast with regards to reporting the primary energy consumption and the consideration of including alternative energy systems in the new building design.
17. October 2016: Revised thermal capacity for the Notional building's roofs and walls.

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INTRODUCTION

1 This document, which takes effect on 1 October 2010, gives guidance on the use of the government's Simplified Building Energy Model (SBEM) and other approved software tools comprising the National Calculation Methodology (NCM) when:

a. demonstrating compliance with the carbon emission requirements of the Building Regulations[1] for England and Wales in respect of buildings other than dwellings.
b. calculating the asset ratings as part of preparing energy performance certificates (EPCs) for buildings other than dwellings.

2 It is expected that separate guidance will be produced by accreditation bodies regarding the forward transmission of the results of these calculations for the purposes of lodgement on the national register and the formal issue of EPCs and recommendation reports to building owners.

3 Separate guidance will be published for the application of the methodology when using approved tools to demonstrate compliance with the applicable regulations in Scotland and Northern Ireland.

4 **This document is under continuous review, and will be updated as and when the need for additional clarification is identified. This regular updating will help improve the consistency of application of the various tools to the Building Regulations compliance and energy certification processes.**

Notice of approval

5 The Notice of Approval of the National Methodology for Calculating the Energy Performance of buildings[2] sets out:

a. the methodology for calculating the energy performance of buildings (including methods for calculating the asset rating and operational rating of buildings); and
b. the ways of expressing the energy performance of buildings as calculated in accordance with the methodology, that are approved by the Secretary of State for the purposes of regulation 17A of the Building Regulations 2000 as amended by the Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007.

6 Associated with the Notice of Approval are tables showing when individual software tools have been approved. This document gives guidance on how those approved software tools should be used:

a. For demonstrating compliance with regulation 17C of the Building Regulations; and
b. For calculating the Asset Rating as part of the production of an EPC.

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[1] Building Regulations 2000 (SI2000/2531) for England and Wales, as amended by SI 2010:719.

[2] http://www.communities.gov.uk/publications/planningandbuilding/noticeapproval

7 To be approved, the software tool must satisfy the criteria as published by Communities and Local Government. These requirements are updated from time to time, and cover a number of generic issues as follows:

a. The software tool has to demonstrate that the calculations are technically robust, and that they cover a necessary minimum set of energy flows.
b. The software tool has to demonstrate that it follows the procedures for compliance and certification as defined in this document, including the use of the NCM databases, the definitions of Notional and Reference buildings, and other issues as defined from time to time.
c. The software tool has to demonstrate that it reports a minimum set of output parameters, and that these parameters can be passed appropriately to standard modules for:
    i. Compliance checking
    ii. Producing an EPC
    iii. Deriving a set of recommendations for energy efficiency improvements.

8 In addition to ensuring that the software tools are compatible in terms of technical scope, the approval process also checks that the procedural guidance is being followed in terms of the calculation and reporting processes.

Version policy

9 All software tools, including SBEM and approved Dynamic Simulation Models DSMs, evolve with time as improvements are made to functionality and the quality of the underlying algorithms. This means that is necessary to have a procedure whereby new versions can be accepted as appropriate for use within the compliance/ certification process. The following rules define the procedures approved by the Secretary of State:

10 For certifying compliance with Building Regulations:

a. The earliest version of a software tool (i.e. software and NCM databases) that can be used in any initial notification is the latest approved version available 12 months prior to application to building control.
b. Developers can subsequently elect at various key points in the process the version of the tool that they will use for compliance and certification purposes. These key points are:
    i. CO_2 emission rate calculation before commencement of work, and
    ii. CO_2 emission rate calculation after completion.
c. At either (or both) of these stages, developers can elect to adopt a more recently approved version of the tool, but having elected to use a later version, developers cannot subsequently revert to using a previous one.

11 For producing EPCs, the most recently approved version of the adopted software tool must be used, unless the latest version has been released less than one calendar month prior to the assessment date. In such cases, the immediately previous version of the tool may be used.

12 To facilitate this process, part of the procedures for approving a software tool is that a new version must be backwards compatible with all previous versions, i.e. it can either read the data files of previous versions, or a file conversion utility must be provided.

Choosing a software tool

13 All calculation methods involve a degree of simplification, and two classes of software tool are available for use for Building Regulations compliance or EPC generation for buildings other than dwellings:

a. SBEM, the simplified building energy model developed by Communities and Local Government. This can be applied to any building (irrespective of size) although there are some cases as described in paragraphs 15 and 16 where representation of certain building features will require some approximation
b. Approved Dynamic Simulation Models (DSMs). These will be applicable for any building unless an individual DSMs approval specifically excludes certain classes of building or building features. They may prove more flexible than SBEM in handling certain building features, and are also more suited as design support tools (as opposed to carrying out compliance and certification calculations).

14 There are a number of approved software interfaces to SBEM, and these interfaces must also be approved before the overall software tool can be used. *Interface approval as well as software approval is necessary to ensure that procedures are followed appropriately as well as the calculations being carried out correctly.*

SBEM constraints

15 Certain building features are not currently modelled explicitly in SBEM and so representing such features in an adequate way will require somewhat cumbersome data preparation work. This problem is not insurmountable and is most likely to arise where buildings and their systems have features that have properties that vary non-linearly over periods of the order of an hour.

16 Examples of building features where such issues can arise include:

a. Buildings with ventilated double-skin facades
b. Automatic blind control
c. Light transfer between highly glazed internal spaces such as atria or light wells

17 Where these features are found Energy Assessors can expect the need to pay more attention to manipulating input data and recording any assumptions made and their justifications.

COMPLIANCE WITH BUILDING REGULATIONS

18 This section of the manual defines the basis for setting the 2010 Target Emission Rate (TER). Regulation 17C requires that all new buildings must achieve or better this target. The TER is based on the performance of the Notional building (see below), and the following procedure must be followed in order to establish the TER. The procedure converts calculated building loads into energy (and hence CO_2 emissions) using seasonal efficiency parameters. *This approach is adopted to avoid the need to define appropriate system models appropriate to each type of building. It also ensures a consistent approach to the target setting process.*

THE NOTIONAL BUILDING

19 The Notional building must have the same size, shape and zoning arrangements as the Actual building, with the same conventions relating to the measurement of dimensions.

20 Each space must contain the same activity (and therefore the same activity parameter values) as proposed for the equivalent space in the Actual building. The activity in each space must be selected from the list of activities as defined in the NCM Activity database, see paragraph 163.

21 The Notional building must be given the same orientation and be exposed to the same weather data as the Actual building. For DSM software the Notional building must be subject to the same site shading from adjacent buildings and other topographical features as are applied to the model of the Actual building.

22 Whatever system type (heating, ventilation, cooling) is specified in a zone in the Actual building must also be provided in the Notional building. Note that in some zones, heating need not be provided, even though the NCM database specifies a heating set-point. For example, the Actual building may contain an unheated stairwell or atrium space. The corresponding zones in the Notional building must also be unheated. However, if heating were provided to either of these spaces in the Actual building, then heating must correspondingly be specified in the Notional, and then both buildings must heat those spaces to the heating set-point specified for the zone type in the NCM database.

23 Any building services system not covered by the energy performance requirements in the Building Regulations1 must be ignored in both the Actual and Notional building.

24 The energy performance standards of the Notional building are based on a concurrent specification that delivers a 25% reduction in CO_2 emissions relative to the 2006 standard based on an assumed build mix. This means that some buildings will be required to improve by more than 25%, others by less, but all should achieve the improvement at approximately the same cost of carbon mitigation (see the Part L Impact Assessment[3] for details of the derivation).

[3] Implementation Stage Impact Assessment of Revisions to Parts F and L of the Building Regulations from 2010

Activity glazing class

25 In the Notional building the activity assigned to each zone determines whether the zone will have windows, rooflights, or no glazing at all, regardless of the type of glazing applied to the equivalent zone in the Actual building. The glazing class assigned to each NCM activity is determined in the "Activity" table from the NCM activity database in the "Driver2A" field (i.e. *0 for no-lit activity, 1 for side-lit activity, and 2 for roof-lit activity*).

Building fabric

26 The U-values must be as specified in **Table 1**. All U-values must be calculated following the guidance in BR443[4]. The reference constructions conforming to these U-values are provided in Appendix A of this document. In addition, the general guidance beginning at paragraph 167 must be followed.

Table 1 Construction element U-values and thermal capacity for the Notional building

Exposed element	U-value (W/m²K)	Thermal capacity[5] (kJ/m²K)
Roofs[6] (irrespective of pitch)	0.18	88.3 (1.40 if metal-clad)
Walls	0.26	21.8 (1.40 if metal-clad)
Exposed floors and ground floors (subject to paragraph 33)	0.22	77.7
Windows, roof windows, and roof lights[7]	1.80	-
Vehicle access and similar large doors	1.50	2.1
Pedestrian doors and high usage entrance doors	2.20	54.6
Internal wall	1.80	8.8
Internal floor / ceiling	1.00	71.8 from above / 66.6 from below

27 Zones in the Notional building which use activity types flagged as involving metal cladding in the NCM activity database will use metal-clad construction elements and the associated Psi values from **Table 2** for thermal bridges.

[4] Conventions for U-value calculations, BRE, 2006.

[5] Thermal capacity calculation in EN ISO 13790:2004

[6] Any part of a roof having a pitch greater or equal to 70º is considered as a wall.

[7] This U-value is the overall U-value including the frame and edge effects, and also relates to the performance of the unit in the vertical plane. The U-value must be adjusted for slope as detailed in section 11.1 of BR443.

28 For SBEM the thermal capacity of the construction elements must be as defined in **Table 1**. For DSM software, the construction details in Appendix A provide the necessary technical parameters to account for the effect of thermal capacity. The thermal mass of windows should be ignored.

29 The Notional building does not have curtain walling, even if there is curtain walling in the Actual building.

30 Smoke vents and other ventilation openings such as intake and discharge grilles must be disregarded in the Actual, Notional, and Reference buildings, and their area substituted by the relevant opaque fabric (i.e. immediately surrounding roof or wall).

31 For SBEM and DSM software, the non-repeating thermal bridge heat losses for each element (including windows etc) must be allowed for by adding 10% to the standard area weighted average U-values, or by an equivalent method that satisfies BS EN ISO 14683, and be consistently applied to both Actual and Notional buildings. Note that the U-values as given in **Table 1** and the corresponding construction elements in the database DO NOT include this allowance, so the calculation tool must make the adjustment explicitly.

32 Where an equivalent method that satisfies BS EN ISO 14683 is used to take account of non-repeating thermal bridges, the Psi values for the Notional building will use the values from **Table 2**.

Table 2 Psi values for the Notional building (W/mK)

Type of junction	Involving metal cladding	Not involving metal-cladding
Roof to wall	0.28	0.12
Wall to ground floor	1.0	0.16
Wall to wall (corner)	0.2	0.09
Wall to floor (not ground floor)	0.0	0.07
Lintel above window or door	1.0	0.30
Sill below window	0.95	0.04
Jamb at window or door	0.95	0.05

33 Special considerations apply to ground floors, where the U-value is a function of the perimeter/area ratio. The following adjustments must be made[8]:

a. If the calculated value is greater than 0.22 W/m²K, the value of 0.22 W/m²K must be used in the Notional building.
b. If the calculated value is less than 0.22 W/m²K with no added insulation, this lower value must be used in the Notional building.

[8] This follows the guidance given in CIBSE Guide A (2006)

34 When modelling an extension, the boundary between the existing building and the extension must be disregarded (i.e. assume no heat transfer across it).

35 Zones in the Notional building which use activity types flagged as involving metal cladding in the NCM activity database, and where the total floor area of the building is ≤ 3500 m^2, will have an air permeability of 7 m^3/h per m^2 envelope at 50 Pa. In all other cases, the air permeability of the Notional building must be 5 m^3/h per m^2 envelope at 50 Pa. The calculation method used to predict the infiltration rate must use the air permeability as the parameter defining the envelope leakage. For compliance and certification, the same method must be used in Actual, Notional, and Reference buildings. Acceptable methods include:

a. The method specified in the SBEM Technical Manual[9], which is taken from EN 15242[10].
b. Other methods that use a relationship between infiltration rate and air permeability and are set out in national or international standards or recognised UK professional guidance documents which relate average infiltration rate to envelope permeability. An example of the latter would be tables 4.13 to 4.20 of CIBSE Guide A (2006).

Methods that use flow networks are not acceptable for compliance or certification purposes, as there is no simple way to check that the permeability of the Notional building delivers the required permeability standard.

Areas of windows, doors and rooflights

36 The areas of windows, doors and roof lights in the Notional building must be determined as set out in the following sub-paragraphs and must also conform to the measurement conventions set out in the guidance beginning at paragraph 187.

a. Copy the areas of high usage entrance, pedestrian, and vehicle access doors that exist in the corresponding element of the Actual building.
b. In the Notional building, high usage entrance, pedestrian, and vehicle access doors must be taken as being opaque (i.e. with zero glazing) and use the U-values in **Table 1**.
c. If the total area of these elements is less than the appropriate allowance for glazing from **Table 3**, the balance must be made up of windows or roof lights as appropriate.
d. If the total area of the copied elements exceeds the allowance for glazing from **Table 3**, the copied areas must be retained but no windows or roof lights added.
e. For DSM software the shape of windows in side-lit activities should be modelled as a full facade width window with sill height of 1.1m. Where doors have been copied across from the Actual building, the window will occupy the remaining facade width, and the height adjusted such that the total area of opening areas still satisfies **Table 3**.

37 Display windows in the Actual building are not copied across into the Notional building.

[9] SBEM Technical Manual (for SBEM version 4) available at www.uk-ncm.org.uk.

[10] Ventilation for buildings – Calculation methods for the determination of air flow rates in buildings including infiltration, EN 15242, CEN/TC 156, 2006

Table 3 Glazing in the Notional building				
Activity glazing class	**Glazing area (glass + frame)**	**g-value (EN ISO 410)**	**Frame factor**	**Visible light transmittance**
Side-lit	Exposed facades will have windows with area that is the lesser of either: 1.5m high × full facade width OR 40% of exposed facade area	0.40	10%	71%
Roof-lit	12% of exposed roof area will be made up of rooflights	0.43	15%	67%
No-lit	No windows or rooflights*	n/a		

*The number of rooflights per roof element is determined using the following equation:

$$\textit{Number of rooflights per roof element} = \frac{\textit{roof element area}}{\left(\frac{1.68 \times \textit{zone height}}{\cos(\textit{angle of slope})}\right)^2}$$

The number of rooflights should be rounded to the nearest integer and be greater than zero. Where the roof element is sloped, the zone height should be the height to the eaves or lowest point of the roof element.

38 DSM software are required to use the glass data provided in **Table 4** and **Table 5** to model the glazing specification required in **Table 3**. Where T_{solar} is the direct solar transmittance, $T_{visible}$ is the direct visible light transmittance, R_{solar} is the solar reflectance, and $R_{visible}$ is the visible light reflectance. The subscripts 1 and 2 refer to the outer and inner surfaces of each pane of glass respectively.

Table 4 Glass properties for side-lit glazing									
	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	6mm	0.409	0.289	0.414	0.798	0.051	0.040	0.837	0.042
Cavity	12mm	Argon gas fill							
Inner pane	6mm	0.783	0.072	0.072	0.889	0.081	0.081	0.837	0.837

Table 5 Glass properties for roof-lit glazing									
	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	6mm	0.447	0.281	0.408	0.739	0.168	0.149	0.837	0.034
Cavity	12mm	Argon gas fill							
Inner pane	6mm	0.783	0.072	0.072	0.889	0.081	0.081	0.837	0.837

39 No glazed area should be included in basements. In semi-basements (i.e. where the wall of the basement space is mainly below ground level but part is above ground), the opening areas in

Table 3 must apply to the above ground part (note that in such situations the 1.1m sill height rule would not need to be followed), with zero glazing for the below ground part.

HVAC system

40 Each space in the Notional building will have the same level of servicing as the equivalent space in the Actual building. In this context, "level of servicing" means the broad category of environmental control, summarised as follows:

a. unheated
b. heated only with natural ventilation
c. heated only with mechanical ventilation
d. air conditioned
e. mixed mode, where cooling only operates in peak season to prevent space temperatures exceeding a threshold temperature higher than that normally provided by a full air conditioning system.

41 A space is only considered as having air-conditioning if the system serving that space includes refrigeration. Night cooling using mechanical ventilation is not air-conditioning. If the same mechanical ventilation system that is used for night cooling is also used to provide normal ventilation, then the space should be regarded as being mechanically ventilated. Any boosted supply rate required to limit overheating must be ignored in the Notional and Actual building. If the mechanical ventilation system only operates in peak summer conditions to control overheating and during normal conditions ventilation is provided naturally, then the space must be regarded as naturally ventilated and the mechanical ventilation system can be ignored in both Notional and Actual buildings.

42 If a zone is naturally ventilated, the modelling strategy must provide for enhanced natural ventilation in the Notional building to prevent overheating. If this is not done, heat will build up and artificially depress the demand for heating the next day, thereby making the energy target unrealistically harsh. For DSM software[11], the following modelling strategy must be used in the Notional building. The strategy must increase the natural ventilation rate up to a maximum of 5 air changes per hour whenever the space temperature exceeds the heating set point[12] by 1K. This enhanced ventilation must cease immediately the space temperature falls below the heating set-point.

By maintaining the increased natural ventilation until internal temperatures fall to the (high) heating set-point, the temperatures at start up next day will be neither artificially high nor low.

43 Humidity control is ignored in the Actual, Notional, and Reference buildings.

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[11] Such an approach is not needed in SBEM, since the form of the model means that there is no feedback between overheating on one day and the energy demands on the next.

[12] This guidance assumes that zone heat output is zero when the heating set point is exceeded. If models use a proportional band to modulate heating output, the heating set-point in this context should be regarded as the temperature at the top of the proportional band, not its mid-point.

44 The system performance definitions follow the practice set out in EN 15243[13]:

a. Auxiliary energy is the energy used by controls, pumps and fans associated with the HVAC systems. It is the term described as "fans, pumps, controls" in Energy Consumption Guides such as ECG019[14].

b. Heating Seasonal Coefficient of Performance (SCoP) is the ratio of the sum of the heating consumption of all spaces served by a system to the energy content of the fuels (or electricity) supplied to the boiler or other heat generator of the system. The SCoP includes boiler efficiency, heat losses in pipe work, and duct leakage. It does not include energy used by fans and pumps (but does include the proportion of that energy that reappears as heat within the system). For DSMs, the ventilation supplied to the zone must be taken as the outdoor air temperature. For SBEM adjusted monthly average figures should be used as specified in the SBEM Technical Manual[9]. Heating energy consumption is therefore calculated from the following expression:

Equation 1 *Heating energy consumption = Zone annual heating load / SCoP*

c. The Seasonal System Energy Efficiency Ratio for cooling (SSEER) is the ratio of the sum of the sensible cooling consumption of all spaces served by a system to the energy content of the electricity (or fuel) supplied to the chillers or other cold generator of the system. The SSEER includes, inter alia, chiller efficiency, heat gains to pipe work and ductwork, duct leakage and removal of latent energy (whether intentional or not). It does not include energy used by fans and pumps (but does include the proportion of that energy that reappears as heat within the system). Electricity used by heat rejection equipment associated with chillers is accounted for in the SSEER (not as auxiliary energy). Electricity used within room air conditioners for fan operation is also included in the SSEER value since it is included in the standard measurement procedure for their EER. Electricity used by fossil- fuelled equipment and its ancillaries, including fans in unit heaters and gas boosters is included in auxiliary energy. For DSMs, the ventilation supplied to the zone must be taken as the outdoor air temperature. For SBEM adjusted monthly average figures should be used as specified in the SBEM Technical Manual[9]. Cooling energy consumption is therefore calculated from the following expression:

Equation 2 *Cooling energy consumption = Zone annual cooling load / SSEER*

45 For the purposes of heating, cooling, and auxiliary energy calculations, the ventilation should operate on a flat profile that is on during the occupied period only, (*i.e. each hour when the NCM daily schedule for occupancy is greater than zero*). The flow rate is determined by the product of the peak occupancy density and fresh air rate per person (both from the NCM Activity

[13] EN 15243, Ventilation for Buildings – Calculation of room temperatures and of load and energy for buildings with room conditioning systems, CEN, 2007

[14] Energy use in offices, Energy Consumption Guide 19, Action Energy, 2003

database). The profile is the same for both natural and mechanical ventilation and does not modulate with the occupancy profile.

46 The Notional building has heat recovery with sensible efficiency of 70%, where appropriate (i.e. zones with mechanical ventilation providing supply and extract), which is bypassed/switched off in cooling mode.

47 The cooling and auxiliary energy must be taken to be powered by grid- supplied electricity.

48 In air-conditioning mode, the cooling SSEER is 3.6, which already takes account of 20% distribution losses and fan energy associated with heat rejection.

49 In mixed-mode operation the Notional building will have cooling SSEER of 2.70 with cooling set-point of 27°C (*note that the SSEER already includes an allowance for fan power*).

50 The fuel and associated Seasonal Coefficient of Performance (SCoP) for space heating and hot water generation in each zone of the Notional building is linked to the type of fuel used for space heating and hot water in the equivalent zone in the Actual building, based on the values provided in **Table 6** and **Table 7**. Space heating and hot water generation are considered independently, for example if a zone in the Actual building uses electric heat pumps for space heating and natural gas for hot water generation, then the equivalent zone in the Notional building will use electric heat pumps for space heating and natural gas for hot water generation. Note that the SCoP values already take account of distribution losses of 10% for space heating and 5% for hot water.

Table 6 Heat generator SCoP and emission factors for side-lit and no-lit activities

Heating fuel used in the Actual building	Space heating	Hot water	CO_2 emission factor ($kgCO_2/kWh$)
Bio-fuels (i.e. emission factor <0.075 $kgCO_2/kWh$)	63.0%	66.5%	The factor for the particular bio-fuel
Natural gas	79.2%	83.6%	0.198
LPG			0.245
Fuel oil			0.297
Electric heat pump	243.0%	256.5%	0.517
Non-electric heat pump	126.0%	133.0%	The factor for the particular fuel
Electricity (direct)	79.2%	83.6%	0.297
Other fuels (i.e. emission factor >0.297 $kgCO_2/kWh$)			

Table 7 Heat generator SCoP and emission factors for roof-lit activities

Heating fuel used in the Actual building	Space heating	Hot water	CO_2 emission factor ($kgCO_2/kWh$)
Bio-fuels (i.e. emission factor <0.075 $kgCO_2/kWh$)	63.0%	66.5%	The factor for the particular bio-fuel

Natural gas	86% for radiant heating* otherwise 81%	85.5%	0.198
LPG			0.245
Fuel oil			0.297
Electric heat pump	243.0%	256.5%	0.517
Non-electric heat pump	126.0%	133.0%	The factor for the particular fuel
Electricity (direct)	86% for radiant heating* otherwise 81%	85.5%	0.297
Other fuels (i.e. emission factor >0.297 kgCO2/kWh)			
*Where a zone in the Actual building only receives heating (i.e. if there is mechanical ventilation it does not provide heating and/or cooling), then the equivalent zone in the Notional Building will be modelled with direct fired multi-burner radiant heating where the thermal efficiency is 86%, and 65% of the thermal output is radiant (i.e. radiant component of 0.65). Zones with roof-lit activities tend to be large/tall spaces where direct radiant heating allows a lower air temperature for a given level of thermal comfort, and this reduces ventilation losses. The SBEM Technical Manual[9] provides the method used by SBEM to account for the benefit of radiant heating, and DSM software should model the radiant effect of this type of heating system to at least an equivalent level of detail as SBEM. Note that direct-fired radiant heating systems do not incur auxiliary energy for pumps or fans.			

51 For hot water the energy demand must be taken as that required to raise the water temperature from 10°C to 60°C based on the demands specified in the activity database. The activity database defines a daily total figure in l/m²per day. If users of DSMs wish to distribute this demand over the day, then the daily total should be distributed according to the occupancy profile.

52 For district heating systems, the fuel emission factor for space heating and hot water in the Notional building will be the same as that used for the Actual building. The SCoP for space heating will be 63.0% if the emission factor is less than or equal to 0.15 $kgCO_2$/kWh, or 79.2% if the emission factor is greater than or equal to 0.20 $kgCO_2$/kWh. The SCoP for hot water will be 66.5% if the emission factor is less than or equal to 0.15 $kgCO_2$/kWh, or 83.6% if the emission factor is greater than or equal to 0.20 $kgCO_2$/kWh. Where the emission factor is between 0.15 and 0.20 $kgCO_2$/kWh, the SCoP is calculated by linear interpolation.

53 For bivalent heating systems (i.e. where more than one fuel is used, such as a biomass boiler supplemented by a natural gas boiler), a demand weighted conversion factor will be calculated for the Notional building that is based on the proportion of heating demand of each fuel type in the Actual building. This calculation is determined at zone level, where for each fuel type the proportion of heating demand is multiplied by the appropriate emission factor and then divided by the associated SCoP, both from **Table 6** or **Table 7**. This is repeated for each fuel type and then summed to determine the demand weighted conversion factor.

For example, if a zone with a side-lit activity in the Actual building meets 70% of its space heating demand with biomass, and the rest with natural gas, then the equivalent zone in the Notional building would use a demand weighted conversion factor of ((0.7×0.013/0.630)+(0.3×0.198/0.792))=0.089*. Note that the demand weighted conversion factor already takes into account both fuel emission factor and the* SCoP*.*

Auxiliary energy

54 The auxiliary energy is the product of the auxiliary power density and annual hours of operation of the heating system as taken from the activity database (*i.e. the hours when the heating set-point is above the set-back temperature based on the daily/weekly/annual schedules or the "SYS_HEAT_T_HOURS_#" from the "activity_sbem_D1_ACU" table in the NCM activity database*).

55 The auxiliary power density is the sum of the pump and fan power density.

56 The pump power density for the Notional building will be zero in zones with roof-lit activities satisfying the conditions in the footnote in **Table 7**. In all other cases, the pump power density for the Notional building will depend on the HVAC system configuration in the Actual building so that:

- if the Actual building's HVAC system is a wet system, the pump power density for the Notional building is 0.30 W/m² where the HVAC system only provides heating, and 0.90 W/m² if it provides air-conditioning;
- if the HVAC system in the Actual building is based on a dry system (e.g. split system), then the Notional building will have zero pump power.

57 For zones where the ventilation system also provides heating and/or cooling, the fan power density is determined for each zone using the following equations:

Equation 3 $Fan\ power\ density = Lesser\ of\ (FPS_1, FPS_2)$

Equation 4 $FPS_1 = FAR_{max} \times SFP_{central} + SCR \times SFP_{terminal}$

Equation 5 $FPS_2 = Greater\ of\ (FAR_{max}, SCR) \times SFP_{central}$

Where $SFP_{central} = 1.80$ *W per l/s and* $SFP_{terminal} = 0.50$ *W per l/s*

"FAR_{max}*" is the peak fresh air supply rate (l/s/m²) that is set by the NCM activity type, while "SCR" is the space conditioning supply rate (i.e. the air flow rate needed to condition the space, in l/s/m²), and is calculated as follows:*

Equation 6 $SCR = Greater\ of\ (PSH, PSC) / (\rho \times C_p \times \Delta T)$

Where $\rho = 1.2$ *kg/m³,* $C_p = 1.018$ *kJ/kgK, and* $\Delta T = 8$*K*

"PSH" is the peak space heating load and "PSC" is the peak space cooling load (i.e. in W/m² of floor area for each zone). For both parameters, the effects of thermal mass will be ignored. The peak space heating load is the sum of the steady state peak fabric losses and infiltration load based on an external ambient of 0°C. The peak space cooling load is the sum of the individual peaks for occupancy, equipment, general lighting, display lighting, and solar. For SBEM the peak solar gain is calculated using the solar data for September from Table 2.30 of CIBSE Guide A (using the beam and diffuse solar for each hour between 06:30 and 18:30). The total solar gain for each room is

calculated and the peak hour is used. DSM software will use the peak solar calculated during simulation.

58 For zones where the ventilation system does not provide heating or cooling (but can include heat recovery) the fan power density is the product of the fresh air supply rate for the NCM activity type and a specific fan power of 0.90 W per l/s.

59 For zones with local mechanical extract the fan power density is the product of the user defined extract rate and a specific fan power of 0.40 W per l/s. For zones where the mechanical extract is remote from the zone the fan power density is the product of the user defined extract rate and a specific fan power of 0.60 W per l/s. Note that the user-defined extract rate is not considered in the air load calculations.

60 The extract fan energy will be an addition to the fan energy for supply ventilation.

61 The Notional building does not have demand control of ventilation.

62 The Notional building has power factor above 0.95, and automatic monitoring and targeting with alarms for out of range values (i.e. the adjustment factors from ADL2A (2010) Table 2 apply).

Lighting power density

63 The general lighting in the Notional building is based on lighting with efficacy of 55 luminaire lumens per circuit-watt, and the resulting power density (W/m²) will vary as a function of the geometry of each zone modelled, which will be determined using the following equation:

Equation 7 $$\textit{Power density per 100 lux} = 2.11 + 0.008 \times R + 0.069 \times R^2$$

Where R is the ratio of the total wall area[15] to the total floor area, where the maximum value for R is 8. The power density per 100 lux is then multiplied by the illuminance level for the activity type, which is determined by the NCM activity database and divided by 100. This equation was derived using regression analysis of parametric results produced using lighting design software for a range of space geometries and lighting systems.

64 Zones in the Notional building which receive natural daylight and use activity types flagged as having daylight harvesting in the NCM activity database, will be modelled with photo-electric dimming (as defined in the SBEM Technical Manual[9]), without back-sensor control and with continuous (i.e. always on) parasitic power that is the lesser of either: 3% of the installed lighting load or 0.3 W/m².

65 Zones in the Notional building that do not receive natural daylight or are flagged in the NCM activity database as appropriate to employ local manual switching, will be modelled with local manual switching (as defined in the SBEM Technical Manual[9]) provided the floor area for each zone is less than 30 m².

[15] For the purposes of the lighting power density calculation, the total wall area includes exposed facades and internal partitions, but not virtual partitions/walls used to define perimeter zones in open plan areas. The floor area should exclude voids in the floor or virtual ceilings.

66 The display lighting in the Notional building is based on the display lighting power density from the NCM activity database multiplied by 0.682 (i.e. adjustment between lamp efficacy of 22 and 15). Daylight harvesting and local manual switching do not apply to display lighting in the Notional building (i.e. only affects general lighting).

67 The general lighting in the Notional building does not benefit from occupancy sensor control.

68 The display lighting in the Notional building does not benefit from automatic time switch control.

69 Both general lighting and display lighting (where appropriate) will use the same operating profile as defined in the NCM activity database for each activity.

The target emission rate (TER)

70 The TER is the CO_2 emission rate of the 2010 Notional building.

THE ACTUAL BUILDING

71 The following outlines specific requirements for how the Actual building is modelled that apply to both SBEM and DSM software.

Building fabric

72 Smoke vents and other ventilation openings such as intake and discharge grilles must be disregarded in the Actual, Notional, and Reference buildings, and their area substituted by the relevant (i.e. immediately surrounding) opaque fabric (roof or wall)

73 For SBEM and DSM software, the non-repeating thermal bridge heat losses for each element (including windows etc) must be allowed for by adding 10% to the standard area weighted average U-values, or by an equivalent method that satisfies BS EN ISO 14683, and be consistently applied to both Actual and Notional buildings.

74 Where an equivalent method that satisfies BS EN ISO 14683 is used to take account of non-repeating thermal bridges in the Actual building, the user will have the option of either directly entering the relevant Psi values or to use defaults as specified in **Table 8** (*based on BRE IP 1/06[16] values degraded by the greater of 0.04 W/mK or 50%*). Where the user directly enters the Psi value, there will be the option of specifying whether the Psi value modelling is the subject of third party quality assurance through an Accredited Construction Details scheme, or carried out by a person suitably qualified to do so following the guidance in BR497[17] in which case Psi values will be degraded by 25% or 0.02 W/mK (whichever is greater). Where a degraded Psi value is worse than the appropriate default value from **Table 8**, it will be capped at the default value.

Table 8 Default Psi values for the Actual building (W/mK)

Type of junction	Involving metal cladding	Not involving metal cladding
Roof to wall	0.42	0.18
Wall to ground floor	1.73	0.24
Wall to wall (corner)	0.38	0.14
Wall to floor (not ground floor)	0.04	0.11
Lintel above window or door	1.91	0.45
Sill below window	1.91	0.08
Jamb at window or door	1.91	0.09

[16] IP 1/06 Assessing the effects of thermal bridging at junctions and around openings in the external elements of buildings, BRE, 2006.

[17] BR497 Conventions for calculating linear thermal transmittance and temperature factors, BRE, 2007.

Lighting

75 Lighting is defined at zone level. The user sets the power density per 100 lux for each zone, this value is multiplied by the illuminance level for the activity assigned to the zone and divided by 100 to arrive at the general lighting power density (W/m²).

76 For building regulations compliance, the general lighting can be defined explicitly or by inference, but the resulting wattage in each zone must be reported in the BRUKL (compliance output document) summary.

77 For general lighting, the following inference methods can be used in addition to the explicit method for Building Regulations compliance to define the general lighting:

Inference method 1 - User sets the Lamp efficacy in lumens per circuit-watt and the light output ratio of the luminaire, to determine the efficacy of the lighting system in terms of luminaire lumens per circuit-watt, which can be pro-rated against the Notional lighting curve (*which is based on 55 luminaire lumens per circuit-watt*) defined by Equation 7 to infer a power density per 100 lux for the general lighting.

Inference method 2 - User assigns a lamp type to each zone based on **Table 9**, where the luminaire efficacy can be pro-rated against the Notional lighting curve (*which is based on 55 luminaire lumens per circuit-watt*) defined by Equation 7 to infer a power density per 100 lux for the general lighting.

Table 9 Lamp inference data

Lamp type	Luminaire lumens per circuit-watt	
	Side-lit and no-lit activities	Roof-lit activity
LED	27.5	33.0
Tungsten and Halogen	7.5	9.0
Fluorescent - compact	22.5	27.0
T12 Fluorescent - halophosphate - low frequency ballast	25.0	30.0
T8 Fluorescent - halophosphate - low frequency ballast	27.5	33.0
T8 Fluorescent - halophosphate - high frequency ballast	32.5	39.0
T8 Fluorescent - triphosphor - high frequency ballast	36.3	43.5
Metal Halide	25.0	39.0
High Pressure Mercury	22.5	27.0
High Pressure Sodium	35.0	42.0
T5 Fluorescent - triphosphor-coated - high frequency ballast	37.5	45.0
Fluorescent (no details)	22.5	27.0

78 The general lighting in the Actual building will include the capability of modelling daylight harvesting, local manual switching (where appropriate), and occupancy sensor control (as defined in the SBEM Technical Manual[9]).

79 The daylight contribution from display windows should be included in the consideration of daylight harvesting.

80 Display lighting will be defined in terms of the average display lighting lamp efficacy for each zone, which will be pro-rated against an efficacy of 15 lamp lumens per circuit-watt to adjust the NCM display lighting value associated with the activity.

81 For Building Regulations compliance, any zone where the display lighting has efficacy less than 22 lamp lumens per circuit-watt will be reported in the BRUKL (compliance output document) summary as failing Criterion 2.

82 There will be an option for assigning automatic time switching control at zone level to display lighting in the Actual building that will result in the annual display lighting energy being reduced by 20%.

83 Both general lighting and display lighting (where appropriate) will use the same operating profile as defined in the NCM activity database for each activity.

Auxiliary energy

84 The following paragraphs outline how auxiliary energy should be calculated for both SBEM and DSM software.

85 DSM software should not allow the user to directly set the auxiliary power density. The users of DSM software should only be allowed to define the HVAC systems type, specific fan powers, and associated controls (i.e. demand control ventilation, variable speed pumping, etc).

86 The auxiliary energy is the product of the auxiliary power density and annual hours of operation of the heating system from the activity database (*i.e. the hours when the heating set-point is above the set-back temperature based on the daily/weekly/annual schedules or the "SYS_HEAT_T_HOURS_#" from the "activity_sbem_D1_ACU" table in the NCM activity database*).

87 The auxiliary power density is the sum of the pump and fan power density.

88 The pump power density for the Actual building will depend on the type of HVAC system and whether the pump has variable speed control. **Table 10** determines which HVAC system types need to account for pump power and whether the option of specifying variable speed pumping is made available to the user. **Table 11** gives the pump power densities for constant speed pumping as well as variable speed pumping.

Table 10 Assigning pump power to HVAC systems

HVAC system type	Pump power	Variable speed pumping allowed
Central heating using water: radiators	LTHW only	Yes
Central heating using water: convectors	LTHW only	Yes
Central heating using water: floor heating	LTHW only	Yes

Central heating with air distribution	None	No
Other local room heater - fanned	None	No
Other local room heater - unfanned	None	No
Unflued radiant heater	None	No
Flued radiant heater	None	No
Multiburner radiant heaters	None	No
Flued forced-convection air heaters	None	No
Unflued forced-convection air heaters	None	No
Single-duct VAV	Both LTHW and CHW	No
Dual-duct VAV	Both LTHW and CHW	No
Indoor packaged cabinet (VAV)	Both LTHW and CHW	Yes
Fan coil systems	Both LTHW and CHW	Yes
Induction system	Both LTHW and CHW	Yes
Constant volume system (fixed fresh air rate)	Both LTHW and CHW	No
Constant volume system (variable fresh air rate)	Both LTHW and CHW	No
Multizone (hot deck/cold deck)	Both LTHW and CHW	No
Terminal reheat (constant volume)	Both LTHW and CHW	No
Dual duct (constant volume)	Both LTHW and CHW	No
Chilled ceilings or passive chilled beams and displacement ventilation	Both LTHW and CHW	Yes
Active chilled beams	Both LTHW and CHW	Yes
Water loop heat pump	Both LTHW and CHW	No
Split or multi-split system	None	No
Single room cooling system	None	No

Table 11 Pump power density for Actual building (W/m²)

Pump configuration	LTHW only	Both LTHW and CHW
Constant speed pumping	0.6	1.8
Variable speed pumping with differential sensor across pump	0.5	1.5
Variable speed pumping with differential sensor in the system	0.4	1.1
Variable speed pumping with multiple pressure sensors in the system	0.3	0.9

89 For zones where the ventilation system also provides heating and/or cooling, the fan power density is determined for each zone using one of the following equations as determined by table 12:

Equation 8 $FPS_1 = FAR_{max} \times SFP_{central} + SCR \times SFP_{terminal}$

Equation 9 $FPS_2 = Greater\ of\ (FAR_{max}, SCR) \times SFP_{central}$

Equation 10 $FPS_3 = Greater\ of\ (SCR/5, FAR_{max}) \times SFP_{central}$

Equation 11 $FPS_4 = FAR_{max} \times SFP_{central}$

"FAR_{max}" is the peak fresh air supply rate (l/s/m²) that is set by the NCM activity type, while "SCR" is the space conditioning supply rate (i.e. the air flow rate needed to condition the space, in l/s/m²), and is calculated as follows:

Equation 12 $SCR = Greater\ of\ (PSH, PSC) / (\rho \times C_p \times \Delta T)$

Where ρ =1.2 kg/m³, C_p =1.018 kJ/kgK, and ΔT =8K

"PSH" is the peak space heating load and "PSC" is the peak space cooling load (i.e. in W/m² of floor area for each zone). For both parameters, the effects of thermal mass will be ignored. The peak space heating load is sum of the peak steady state fabric losses and infiltration load based on an external ambient of 0°C.

For SBEM the peak space cooling load is the sum of peak internal gains, which will include occupancy, equipment, general lighting, display lighting, and peak solar gains. The peak solar gain is calculated using the solar data for September from Table 2.30 of CIBSE Guide A (using the beam and diffuse solar for each hour between 06:30 and 18:30). The total solar gain for each room is calculated and peak hour is used. DSM software are allowed to use the peak solar calculated during simulation.

90 The fan power density equations are assigned to HVAC systems based on **Table 12**.

Table 12 Assigning fan power equations to HVAC systems

HVAC system type	SBEM ID	Fan power density
Fan coil systems	4	Equation 8
Indoor packaged cabinet (VAV)	32	
Central heating using air distribution	2	Equation 9
Constant volume system (fixed fresh air rate)	5	
Constant volume system (variable fresh air rate)	6	
Single-duct VAV	7	
Water loop heat pump	13	

Dual duct (constant volume)	15	
Multi-zone (hot deck/cold deck)	16	
Terminal reheat (constant volume)	17	
Dual-duct VAV	31	
Active chilled beams	12	Equation 10
Induction system	14	
Chilled ceilings or passive chilled beams and displacement ventilation	11	Equation 11

91 For zones where the ventilation system does not provide heating or cooling (but can include heat recovery) the fan power density is the product of the fresh air supply rate for the NCM activity type and the specific fan power defined by the user at zone level.

92 For zones with mechanical extract the fan power density is the product of the user defined extract rate and the specific fan power defined by the user. The extract fan energy will be an addition to the fan energy for supply ventilation. Note that the user defined extract rate is not considered in the air load calculations.

DEMAND CONTROL VENTILATION

93 The Actual building will include the ability to model demand control ventilation for zones with mechanical ventilation (but excluding extract only systems) while for naturally ventilated zones there will be the option of enhanced ventilation control. The details for implementing demand control ventilation is outlined as follows:

94 For zones with mechanical ventilation (but excluding extract only ventilation), then the following options will become available:

1. No demand-controlled ventilation (default option)
2. Demand Control based on occupancy density
3. Demand control based on gas sensors

95 If the option selected is either 2 or 3 from above, then the parameter “air flow regulation type” will become active with the following available options:

1. Damper control (default option)
2. Speed control

96 For zones with natural ventilation, then the options available will be:

1. No demand-controlled ventilation (default option)
2. Enhanced ventilation

97 Depending on user inputs, a modified demand control fresh air rate (FAR_{dc}) is determined from the NCM fresh air rate (FAR_{max})

Equation 13 $$FAR_{dc} = C_{dc} \times FAR_{lower} + (1 - C_{dc}) \times FAR_{max}$$

where :

FAR_{max} is the ventilation rate per person from the NCM activity database multiplied by the peak occupancy density during the occupied period (i.e. l/s/m²).

FAR_{min} is the ventilation rate per person from the NCM activity database multiplied by the minimum occupancy density during the occupied period (i.e. this can be zero for some activities).

FAR_{lower} is the greater of either: FAR_{min} or $0.6 \times FAR_{max}$.

C_{dc} = is a demand control coefficient and is determined based on the data in **Table 13**.

Table 13 Values for demand control coefficient

Type of demand control	Demand control Coefficient (C_{dc})
None	0
Control based on occupancy density	0.85
Control based on gas sensor	0.95
Enhanced natural ventilation	0.50

98 In addition to affecting the fresh air load (i.e. energy to heat and cool the fresh air), demand control ventilation can also affect the auxiliary energy. Where the air flow regulation uses fan speed control (i.e. using variable speed fans) the auxiliary energy calculation will use FAR_{dc} instead of FAR_{max}, but if the air flow regulation uses damper control then the auxiliary energy calculation will not be affected.

99 For a more detailed description of the demand control ventilation methodology, please refer to the SBEM Technical Manual[9].

Shell & core

100 For shell and core buildings, users need to identify which services are assumed at the 'as built' stage. Assumed services should be defined at zone level by means of differentiating 'shell' from 'core' zones (approved software tools must allow for this selection).

101 If calculation is performed at 'as built' stage, the proportion of energy associated to HVAC, lighting and HW systems serving 'shell' zones would not be accounted for in the total energy consumption of the building, as well as the associated floor area. Note that those systems are fully operational and calculated so that the expected service is provided, designated temperatures are maintained, lighting and hot water provided in all zones, both 'shell' and 'core'. That means the boundary conditions between the shell and core areas are considered, but no energy is used by the plants or lighting systems when serving 'shell' zones. In all other cases, e.g. analysis performed at 'as design' stage or for 'core' zones, energy would be accounted for as usual. This is applicable to all modelled buildings: Actual, and Notional.

102 Energy produced by renewable energy sources must be apportioned in an area weighted basis when the analysis is done at the 'as built' stage. Only the proportion for 'core' zone areas is accounted for at this stage.

103 The energy associated with CHP systems would only apply to the 'core' areas.

104 These procedures only apply to Building Regulations compliance ('as built' stage), EPC generation will still include both 'shell' and 'core'.

Modular and portable buildings

105 For modular and portable buildings with a planned time of use of more than two years, reasonable provision to demonstrate compliance with Building Regulations could be subject to certain corrections to the TER as specified in ADL2A (2010). Approved tools must allow users to specify the necessary information to apply such adjustments. Users are expected to follow guidance in Approved Documents to correctly populate these fields.

CRITERION 3: LIMITING SOLAR GAINS

106 This section describes how the solar gain limit (i.e. Criterion 3 of ADL2A (2010)) should be checked in the Actual building.

107 Any zone in the Actual building that is either mechanically cooled or has an activity that is flagged in the NCM activity database as being an occupied space will be included in the solar gain limit check.

108 The solar gain in the Actual building is calculated at point of absorption into the internal surfaces of each zone, and includes solar gain absorbed in the glazing and/or blinds, which subsequently enters the space via conduction/radiation/convection.

109 The contribution of solar gain from display windows will be included in the solar gain limit check for zones that apply.

110 The solar gain limit is based on the solar gains through benchmark glazing types described in **Table 14**, and selected according to paragraph 114, aggregated over the period from April to September, and using the same CIBSE TRY weather data used for the criterion 1 CO_2 emission calculations.

Table 14 General description of benchmark glazing for setting solar gain limit

Benchmark glazing type	Description	Glazing dimensions/area
1	Vertical glazing facing East with 10% frame factor and g-value of 0.68	Height of 1m and width equal to the total exposed facade* width of the zone being checked
2	Horizontal glazing with 25% frame factor and g-value of 0.68	Area equal to 10% of the total exposed roof area
3	Horizontal glazing with 15% frame factor and g-value of 0.46	Area equal to 20% of the total exposed roof area

*The exposed facade width should take into account opaque/translucent wall elements, as well as external doors, external windows and curtain walling systems.

111 The treatment of solar gains entering a space will vary between DSM software, so for DSM software it is necessary to define a standard test-space for each benchmark glazing type (Figure 1 to Figure 3) that meets the requirements of **Table 14**. This allows the pre-calculation of the benchmark aggregated solar gain as a function of facade length and exposed roof area (i.e. kWh/m and kWh/m² respectively). This means that each DSM will have 3 values for benchmark aggregated solar flux for each CIBSE TRY weather data set.

112 The standard test-spaces will have solar absorptance of 0.5 for all internal surfaces. The external ground reflectance should be 0.2. The glazing should use the appropriate glass data provided in **Table 15** and **Table 16** (where T_{solar} is the direct solar transmittance, $T_{visible}$ is the direct visible light transmittance, R_{solar} is the solar reflectance, $R_{visible}$ is the visible light reflectance. The subscripts 1 and 2 refer to the outer and inner surfaces of each pane of glass respectively).

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113 During validation, DSM software will be required to declare the benchmark aggregated solar flux values. Once approved by CLG, the declared benchmark aggregated solar flux values cannot be changed unless re-validation is carried out.

114 The solar gain limit is calculated and checked on a zone by zone basis in the Actual building, using the following methods:

a. For zones with side-lit or no-lit activities
   - For each zone with exposed facade area greater than zero, the limiting solar gain will be the aggregated solar flux for benchmark glazing type 1 multiplied by the exposed facade length
   - For each zone with zero exposed facade area (i.e. an internal zone that receives second hand solar), the limiting solar gain will be the aggregated solar flux for benchmark glazing type 2 multiplied by either the projected floor area or the exposed roof area (whichever is greater).

b. For zones with roof-lit activities
   - For each zone where the height[18] is less than 6m, the solar gain limit will be the aggregated solar flux for benchmark glazing type 2 multiplied by either the projected floor area or the exposed roof area (whichever is greater).
   - For each zone where the height[18] is greater than or equal to 6m, the solar gain limit will be the aggregated solar flux for benchmark glazing type 3 multiplied by either the projected floor area or the exposed roof area (whichever is greater).

115 The total solar gain aggregated over the period from April to September for each zone in the Actual building where this criterion applies, will have to be less or equal to the limiting solar gain calculated based on the benchmark glazing types. For DSM software the total solar gain should include external solar gain from all orientations and inclinations as well as any "second hand" solar gain from adjacent zones (i.e. via internal glazing / holes / virtual partitions).

116 The aggregated solar gain should not include the conduction gains via window frames or solar gains through opaque envelopment elements (e.g. sol-air temperature gains through the roof/walls).

Table 15 Glass properties to achieve g-value of 0.68

	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	6mm	0.783	0.072	0.072	0.889	0.081	0.081	0.837	0.837
Cavity	12mm	Argon gas fill							
Inner pane	6mm	0.664	0.111	0.092	0.822	0.109	0.098	0.170	0.837

Table 16 Glass properties to achieve g-value of 0.46

	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	4mm	0.468	0.165	0.185	0.654	0.104	0.026	0.837	0.153
Cavity	12mm	Argon gas fill							
Inner pane	4mm	0.821	0.074	0.074	0.896	0.081	0.081	0.837	0.837

[18] For zones with pitch roofs, use the average height.

Figure 1 Isometric view of standard test-space for benchmark glazing type 1

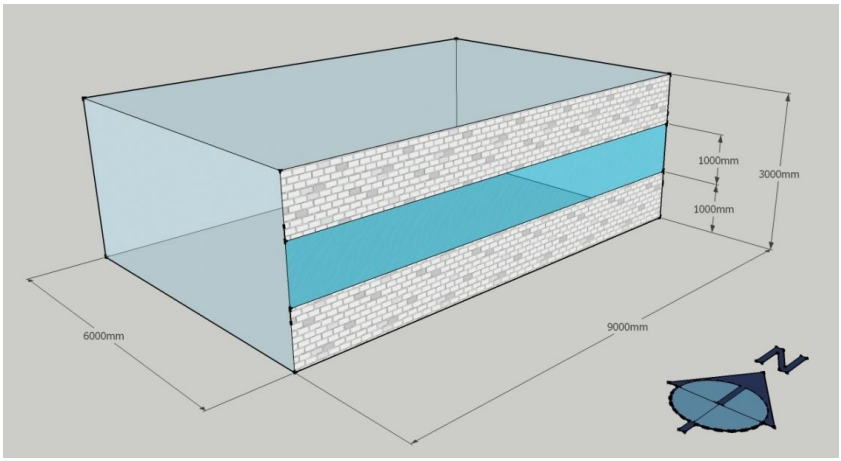


Figure 2 Isometric view of standard test-space for benchmark glazing type 2

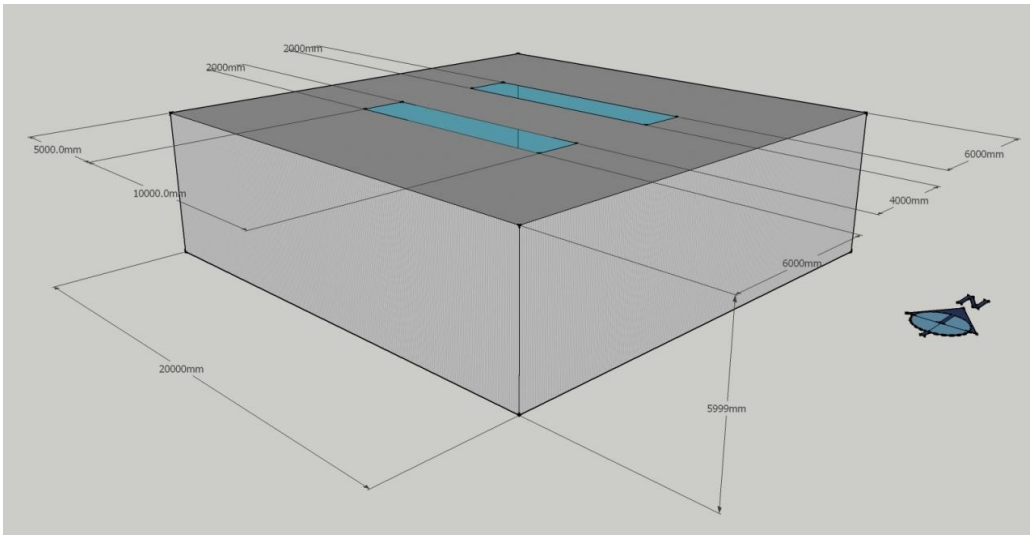
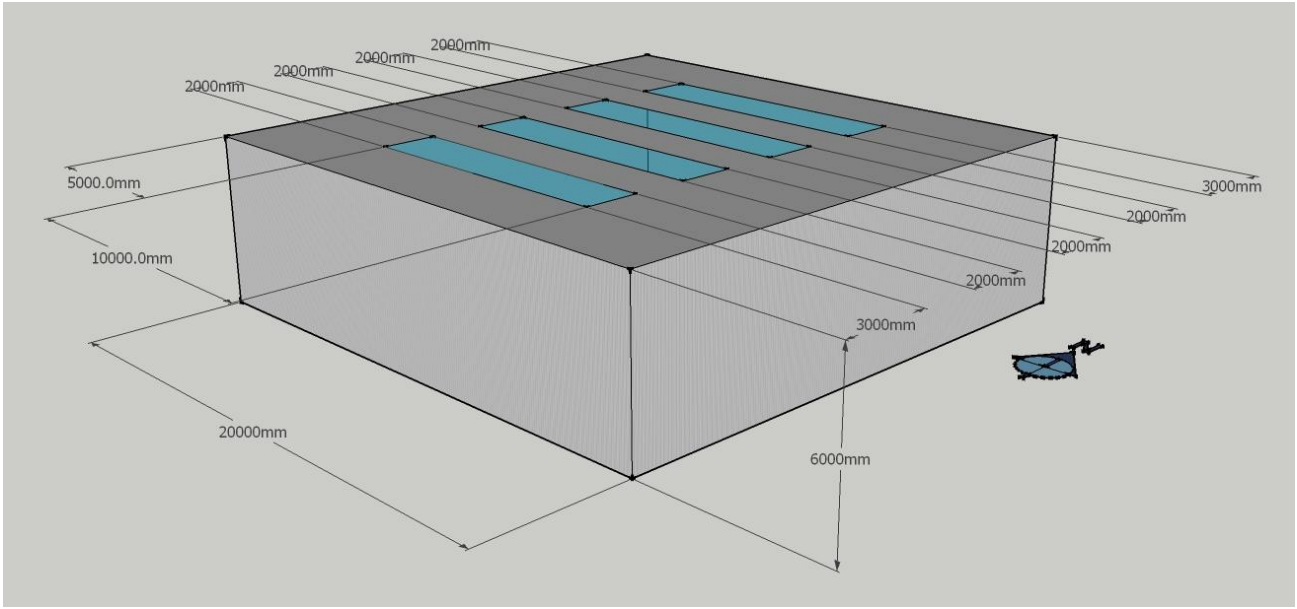


Figure 3 Isometric view of standard test-space for benchmark glazing type 3

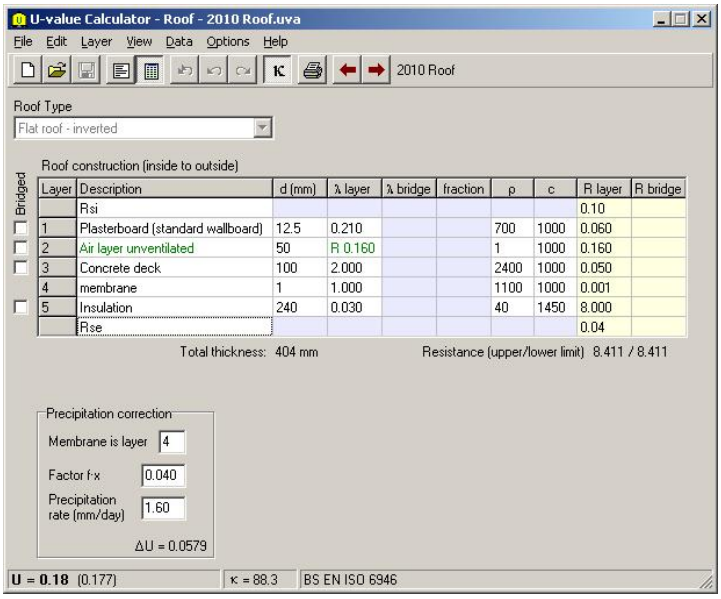


APPENDIX A – CONSTRUCTION DETAILS FOR 2010 NOTIONAL BUILDING

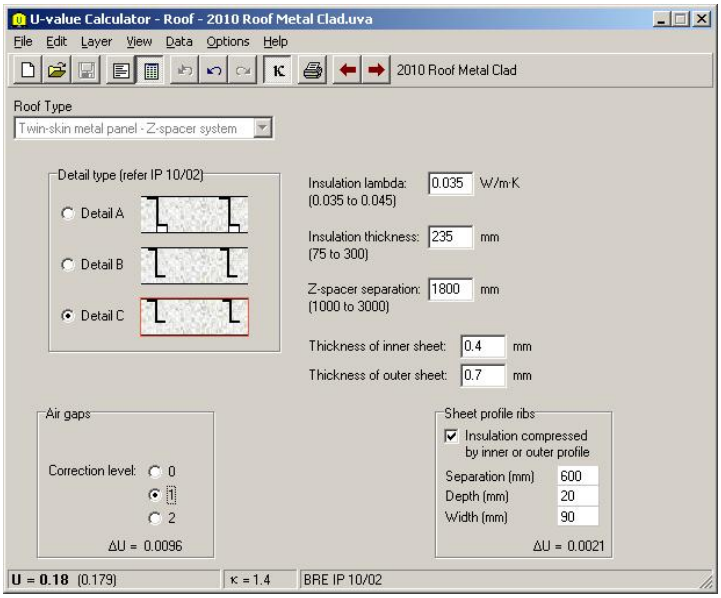
117 This section includes screen grabs from the BRE U-value calculator (version 2.02) that show the construction details used as the basis for the data for thermal capacity values in **Table 1**. These construction details are for use by DSM software to account for the effect of thermal capacity.

118 DSM software generally use less sophisticated methods for calculating the U-value of constructions (i.e. they do not take account of repeating thermal bridges due to fixings, etc). Therefore where appropriate the thickness of the insulation layer should be adjusted to achieve the same U-value as specified in **Table 1**.

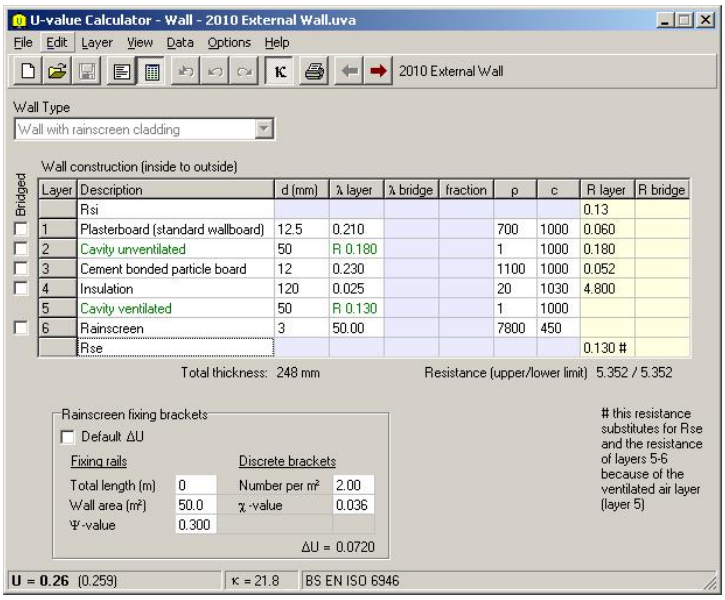
119 Roof construction details for the 2010 Notional building where the Actual building roof is not metal-clad.



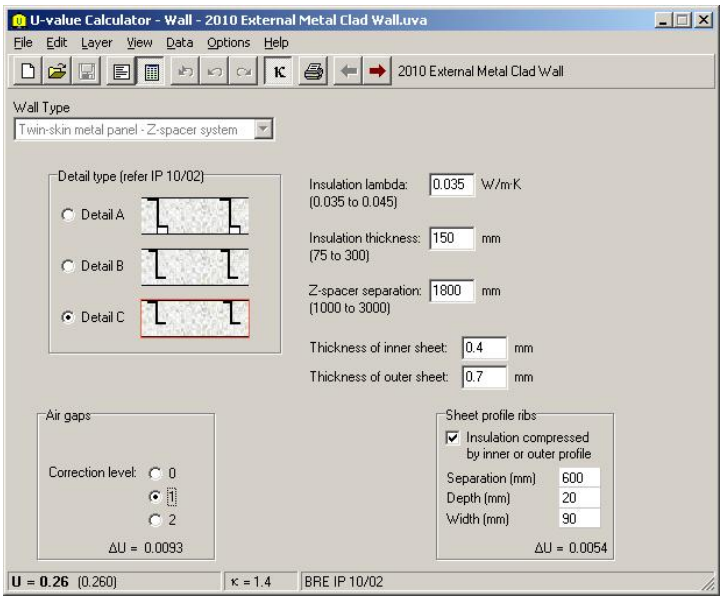
120 Roof construction details for the 2010 Notional building where the Actual building roof is metal cladding.



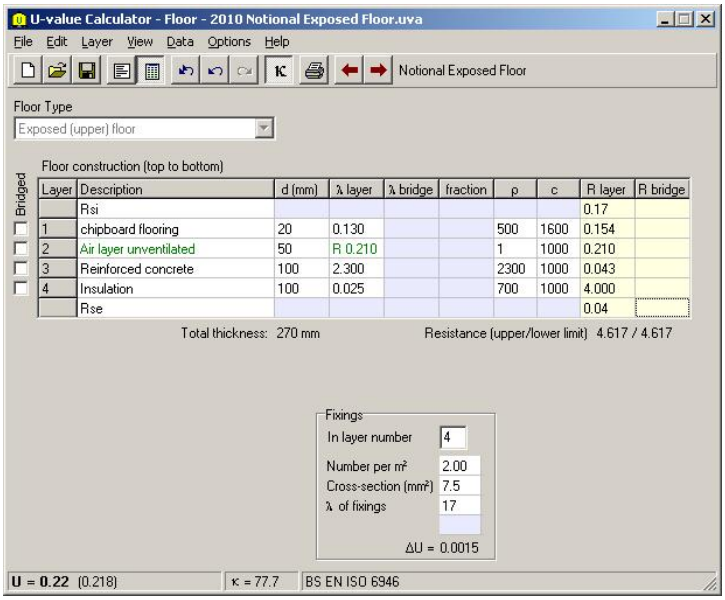
121 External wall construction details for the 2010 Notional building (not involving metal cladding).



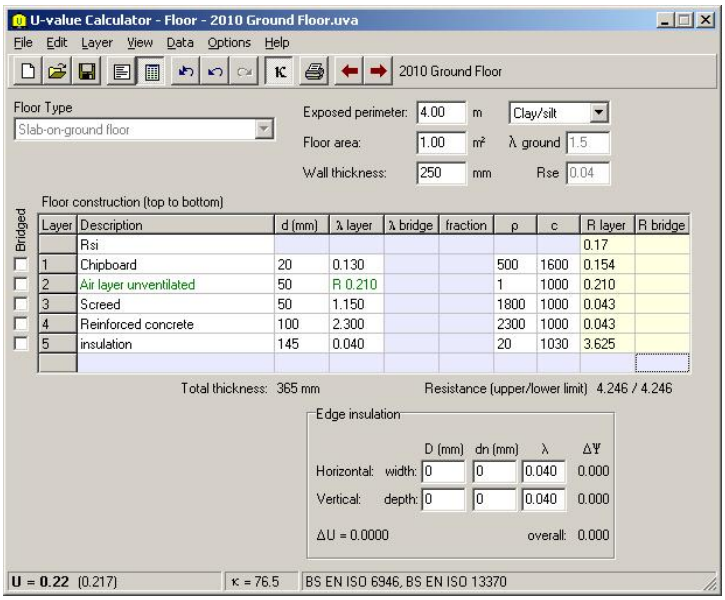
122 External wall construction details for the 2010 Notional building (involving metal cladding).



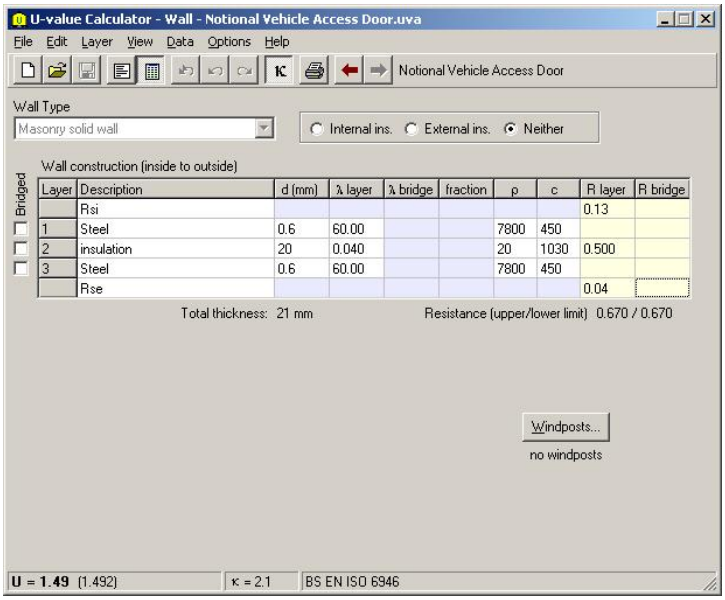
123 Exposed floor construction details.



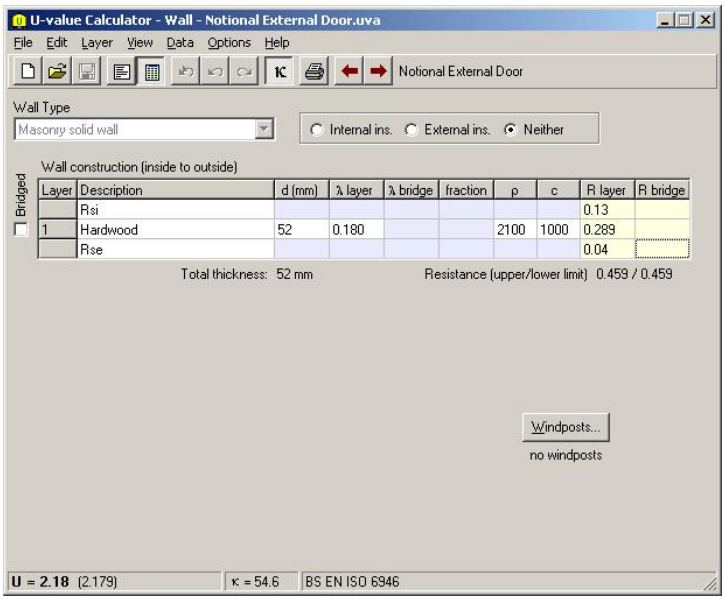
124 Ground floor construction details (*note that the aspect ratio and edge insulation parameters have not been set, as these details are intended only for determining the thermal capacity as view from inside*).



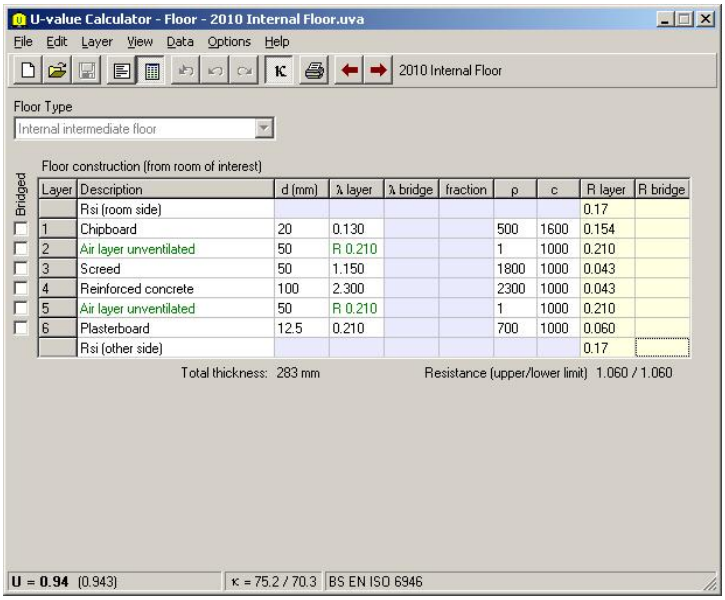
125 Vehicle access and similar large door construction details.



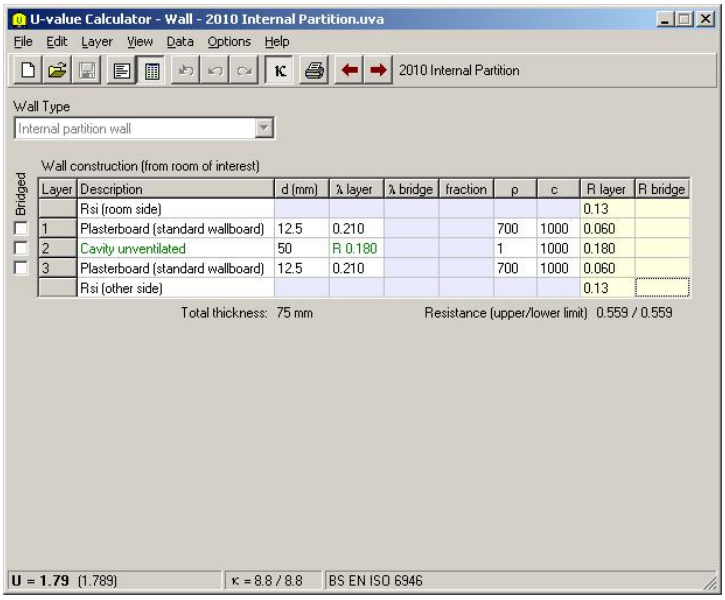
126 Pedestrian doors and high usage entrance doors construction details.



127 Internal floor / ceiling construction details.



128 Internal partition construction details.



APPENDIX B – THE REFERENCE BUILDING

129 This section of the manual defines the reference building, which is the basis of setting the energy rating scale for Energy Performance Certificates (EPCs) for England and Wales. The Asset Rating rates the CO_2 emissions from the Actual building in comparison to a Standard Emission Rate (SER). The Standard Emission Rate is determined by applying a fixed improvement factor to the emissions from a Reference building, which is defined below.

130 EPCs are intended to send market signals about the relative performance of comparable buildings. In order to provide this consistency, the Reference building must be the same irrespective of:

a) Whether the Actual building is naturally ventilated or air conditioned.
b) The fuel choice.

131 The Reference building must have the same size, shape and zoning arrangements as the Actual building, with the same conventions relating to the measurement of dimensions.

132 Each space must contain the same activity (and therefore the same activity parameter values) as proposed for the equivalent space in the Actual building. The activity in each space must be selected from the list of activities as defined in the NCM Activity database, see paragraph 163.

133 The Reference and Actual buildings must be given the same orientation and be exposed to the same weather data. For DSM software the Reference building must be subject to the same site shading from adjacent buildings and other topographical features as are applied to the model of the Actual building.

Building fabric

134 The U-values must be as specified in **Table 17**. All U-values must be calculated following the guidance in BR443. The reference constructions conforming to these U-values are identified in the table by their reference identities. In addition, the general guidance beginning at paragraph 168 must be followed.

Table 17 U-values for the Reference building

Exposed element	U-value (W/m²K)	Database reference ID
Roofs[19] (irrespective of pitch)	0.25	291
Walls	0.35	292
Floors and ground floors (subject to paragraph 137)	0.25	248
Windows, roof windows, roof lights, and curtain walling7	2.20	-
External pedestrian doors (including glazed doors)	2.20	480
Vehicle access and similar large doors	1.50	261
Internal walls	2.00	307
Internal windows	3.85	481
Internal floors (viewed from room above)	1.40	355
Internal floors (viewed from room below)	1.23	315

135 Smoke vents and other ventilation openings such as intake and discharge grilles must be disregarded in the Reference building, and their area substituted by the relevant (i.e. immediately surrounding) opaque fabric (roof or wall).

136 For SBEM and DSM software, the non-repeating thermal bridge heat losses for each element (including windows etc) must be allowed for by adding 10% to the standard U-values. Note that the U-values as given in **Table 17** and the corresponding construction elements in the database DO NOT include this allowance, and so the calculation tool must make the adjustment explicitly.

137 Special considerations apply to ground floors, where the U-value is a function of the perimeter/area ratio. The following adjustments must be made8:

a. If the calculated value is greater than 0.25 W/m²K, the value of 0.25 W/m²K must be used in the Reference building.

[19] Any part of a roof having a pitch greater or equal to 70º is considered as a wall.

b. If the calculated value is less than 0.25 W/m²K with no added insulation, this lower value must be used in the Reference building.

138 When modelling an extension, the boundary between the existing building and the extension must be disregarded (i.e. assume no heat transfer across it).

139 If using SBEM, the thermal capacity of the construction elements must be as defined in **Table 18**. Users of simulation tools must use the construction elements as given in the reference numbers in **Table 17**. The information in the database includes the necessary technical parameters to evaluate the impact of thermal capacity.

Table 18 Thermal capacity of construction elements in the Reference building

Element	**Thermal capacity**5 **(kJ/m²K)**
External wall	11.7
Roof	12.0
Ground floor	36.0
Internal wall	11.9
Internal floor (and ceiling)	8.6

140 The air permeability of the Reference building must be 10 m³/h per m² envelope at 50 Pa. The calculation method used to predict the infiltration rate must use the air permeability as the parameter defining the envelope leakage. For compliance and certification, the same method must be used in Actual, Notional, and Reference buildings. Acceptable methods include:

a. The method specified in the SBEM Technical Manual[9], which is taken from EN 15242[10].
b. Other methods that use a relationship between infiltration rate and air permeability and are set out in national or international standards or recognised UK professional guidance documents which relate average infiltration rate to envelope permeability. An example of the latter would be tables 4.13 to 4.20 of CIBSE Guide A (2006).

Areas of windows, doors and rooflights

141 In SBEM, the total solar energy transmittance (BS EN 410 g-value) and the light transmittance of glazing must be as given in **Table 19**. This data applies to windows, roof windows, and roof lights. Appropriate values for intermediate orientations can be based on linear interpolation.

Table 19 Solar and light transmittances for glazing in the Reference building

Orientation of glazing	Solar transmittance	Light transmittance	Reference glazing type
North, North-East, South, North-West	0.72	0.76	1
East, South-East, South-West, West	0.58	0.61	2
Horizontal	0.43	0.46	3

142 DSM software are required to use the glass data provided in **Table 20**, **Table 21**, and **Table 22** to determine the EN ISO 410 g-value. T_{solar} is the direct solar transmittance, $T_{visible}$ is the direct visible light transmittance, R_{solar} is the solar reflectance, $R_{visible}$ is the visible light reflectance. The subscripts 1 and 2 refer to the outer and inner surfaces of each pane of glass respectively.

Table 20 Glass properties for Reference glazing type 1

	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	6mm	0.821	0.074	0.074	0.913	0.082	0.082	0.837	0.837
Cavity	12mm	Argon gas fill							
Inner pane	6mm	0.664	0.111	0.092	0.822	0.109	0.098	0.170	0.837

Table 21 Glass properties for Reference glazing type 2

	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	6mm	0.655	0.068	0.068	0.735	0.079	0.079	0.837	0.837
Cavity	12mm	Argon gas fill							
Inner pane	6mm	0.664	0.111	0.092	0.822	0.109	0.098	0.170	0.837

Table 22 Glass properties for Reference glazing type 3

	Thickness	T_{solar}	R_{solar1}	R_{solar2}	$T_{visible}$	$R_{visible1}$	$R_{visible2}$	Emissivity 1	Emissivity 2
Outer pane	6mm	0.437	0.052	0.055	0.551	0.060	0.063	0.837	0.837
Cavity	12mm	Argon gas fill							
Inner pane	6mm	0.664	0.111	0.092	0.822	0.109	0.098	0.170	0.837

143 The areas of windows, doors and roof lights in the Reference building must be determined as set out in the following sub-paragraphs and must also conform to the measurement conventions set out in the guidance beginning at paragraph 183.

a. Subject to the following criteria, all external walls must have windows and all roofs must have roof lights.
b. Copy the areas of pedestrian doors, vehicle access doors and display windows that exist in the corresponding element of the Actual building.
c. If the total area of these elements is less than the appropriate allowance from **Table 23**, the balance must be made up of windows or roof lights as appropriate.
d. If the total area of the copied elements exceeds the allowance from **Table 23**, the copied areas must be retained but no windows or roof lights added.
e. The areas as defined in **Table 23** represent the areas of opening in the wall or roof, and comprise the area of the glass plus frame. The windows must have a frame factor of 10% (i.e. 90% of the area of the opening is glazed) and roof lights a frame factor of 30%.

144 The U-value of display windows must be taken as 5.7 W/m²K in the Reference building with solar transmittance6 of 0.77, light transmittance of 0.87, and 10% frame factor.

Table 23 Percentage opening areas in the Reference building

Building type	Windows (of exposed wall area)	Rooflights (of exposed roof area)
Residential buildings (where people temporarily or permanently reside)	30%	20%
Places of assembly, offices and shops	40%	20%
Industrial and storage buildings	15%	20%

145 In addition, the following rules apply:

a. The Reference building does not have any high usage entrance doors, even if these are present in the Actual building.
b. In the Reference building, pedestrian and vehicle access doors must be taken as being opaque (i.e. with zero glazing).
c. No glazed area should be included in basements. In semi-basements (i.e. where the wall of the basement space is mainly below ground level but part is above ground), the **Table 23** percentages must apply to the above ground part, with zero glazing for the below ground part.

HVAC system

146 The heating and hot water service is always met by natural gas irrespective of whether a fuel other than natural gas is used in the Actual building, or is even available in the locality of the Actual building.

147 The Reference building has a fixed servicing strategy regardless of the strategy adopted in the Actual building. Therefore:

a. Each space is heated as defined by the heating set-points defined in the activity database.
b. The heating SCoP is 0.73
c. The auxiliary energy is the product of 0.60 W/m² and the annual hours of operation of the heating system from the activity database (*i.e. the hours when the heating set-point is above the set-back temperature based on the daily/weekly/annual schedules or the "SYS_HEAT_T_HOURS_#" from the "activity_sbem_D1_ACU" table in the NCM activity database*).
d. Each space is cooled, based on the operating schedules defined by the NCM activity database, with the cooling set-point fixed at 27°C irrespective of whether the particular space in the Actual building has cooling provision or not[20] . The cooling SSEER must be taken as 2.25 (this factor includes an allowance for fan energy when the system operates, so no additional auxiliary energy need be determined).

A space that is not treated (i.e. no heating and no cooling) in the Actual building will not be heated or cooled in the Reference building. This means that all potential levels of servicing are accommodated on a single scale. If a particular accommodation type does not need air conditioning (e.g. warehouse), then the cooling demand will be zero and no energy demand will be calculated. If a particular accommodation type always needs cooling (e.g. a dealer room), then a base line level of cooling will be calculated. 27°C has been chosen rather than the usual comfort threshold of 28°C because the calculations are based on the Test Reference Year (representing typical weather).

148 In the Reference building

a. No allowance should be made for heat recovery equipment.
b. No allowance should be made for demand control of ventilation.

149 HWS overall system efficiency (including generation and distribution) must be taken as 45 percent. The energy demand must be taken as that required to raise the water temperature from 10°C to 60°C based on the demands specified in the activity database. The activity database defines a daily total figure in l/(m².day). If users of DSMs wish to distribute this demand over the day, then the daily total should be distributed according to the occupancy profile.

150 The Reference building must be assumed to have no power factor correction or automatic monitoring and targeting with alarms for out of range values.

[20] If the space in the Actual building has a cooling system, then the calculation of the performance of the Actual building will be assessed by cooling the space to the cooling set-point temperature as defined in the activity database. User specified cooling set-points are not allowed.

151 The CO_2 emissions arising from the use of the fixed building services in the Reference building are calculated (the Reference Emission rate or RER), and then adjusted by the relevant improvement factor to arrive at the energy performance used to normalise the CO_2 emissions in the Actual building. This adjusted CO_2 emissions rate is termed the Standard Emission Rate (SER). This means that a gas heated mixed-mode building that is just compliant with Building Regulations (2006) would have an Asset Rating of 100. When making the adjustment, the improvement factor must be taken as 23.5%. In summary:

Equation 14 $SER = RER \times 0.765$

This is the overall improvement required for a heated and naturally ventilated building, compared to 28% for a mechanically ventilated or air-conditioned building as given in ADL2A (2006). The lower figure has been taken, since in most cases, the cooling energy demand will be small and so the building most closely resembles a heated only building. Furthermore, if the Actual building is air conditioned to normal standards (i.e. typically 22-24^{o}C), the Reference building is only cooled to 27^{o}C, which gives the Reference building an advantage against the Notional building that will compensate (to some extent) for the smaller improvement factor compared to that required by Building Regulations.

152 It is not intended that the definition of the Reference building should change as Part L standards change, since this would mean that the energy rating of a given building would also change, even if its energy efficiency had not been varied. Therefore the Reference building is always as defined above.

Lighting power density

153 For general lighting:

a. In office, storage and industrial spaces, divide by 100 the illuminance defined for the space as given in the activity database, then multiply by 3.75 W/m² per 100 lux. This includes all spaces that accommodate predominantly office tasks, including classrooms, seminar rooms and conference rooms, including those in schools.
b. For other spaces, divide the illuminance appropriate to the activity in the space by 100, and then multiply by 5.2 W/m² per 100 lux.

154 Zones in the Reference building that are flagged in the NCM activity database as appropriate to receive local manual switching, will be modelled with local manual switching (as defined in the SBEM Technical Manual[9]) provided the floor area for each zone is less than 30 m². Note that local manual switching only applies to general lighting (i.e. does not apply to display lighting).

155 For display lighting, take the display lighting density appropriate to the activity from the activity parameter database.

156 The general lighting in the Reference building does not benefit from occupancy sensor control.

157 The display lighting in the Reference building does not benefit from automatic time switch control.

158 Both general lighting and display lighting (where appropriate) will use the same operating profile as defined in the NCM activity database for each activity.

Calculating the asset rating

159 The Asset Rating is the ratio of the CO_2 emissions from the Actual building (i.e. the BER) to the Standard Emission Rate, SER, with the result normalised such that the SER is equivalent to an Asset Rating of 50, i.e. AR = 50 × BER / SER. The calculated AR must be rounded to the nearest whole number, i.e. if the decimal part of the AR is less than 0.5, the AR must be rounded down; if it is 0.5 or greater, the AR must be rounded up.

Constructing the rating scale

160 The A to G scale is a linear scale based on two key points defined as follows:

a) The zero point on the scale is defined as the performance of the building that has zero net annual CO_2 emissions associated with the use of the fixed building services as defined in the Building Regulations. This is equivalent to a Building Emissions Rate (BER) of zero.

b) The border between grade B and grade C is set at the Standard Emissions rate (SER) and given an Asset Rating of 50. Because the scale is linear, the boundary between grades D and grade E corresponds to a rating of 100.

Reference values

161 The Energy Performance Certificate must display reference values in addition to the Asset Rating. The Government has decided that the certificate should display two reference values as follows:

a) The Building Regulations standard (i.e. the TER). Note this is based on the performance of the Notional building, not the Reference building.

b) The performance of the Typical building, where the emission rate is equal to the 2010 Notional building emission rate multiplied by 2 and divided by 0.75 (*this is approximately twice the emission rate of the 2006 TER*).

APPENDIX C - INPUT DATA TO APPROVED TOOLS

162 This section describes generally applicable approaches to data input and modelling strategies, and applies equally to Building Regulations compliance and EPCs, and also to the modelling of Actual, Notional, and Reference buildings.

Defining internal gains and environmental conditions

163 In order to facilitate estimating energy performance on a consistent basis, a key part of the NCM is a set of databases that define the activities in various types of space in different classes of building[21]. One of these standard activities must be assigned to each space in the building[22].

164 A 2010 version of the NCM activity database has been created to accompany the 2010 version of the NCM modelling guide. The keys changes to the new activity database are as follows:

- Activities re-organised into use-classes, as defined by the Town and Country Planning (Use Classes) Order 1987
- Addition of new flags to indicate whether an activity is side-lit, roof-lit, or no-lit
- Activities that were previously repeated under multiple building types were rationalised
- Addition of new activities

165 The database provides standard occupancy, temperature set-points, outdoor air rates and heat gain profiles for each type of space in the buildings, so that buildings with the same mix of activities will differ only in terms of their geometry, construction, building services and weather location. Thus it is possible for the Building Regulations Regulation 17C compliance test and EPCs to compare buildings on the basis of their intrinsic potential performance, regardless of how they may actually be used in practice.

166 The fields of information in the database are as follows:

a) Occupancy times and density; total metabolic rate and percentage which is latent (water vapour)
b) Set point temperature and humidity in heating and cooling modes; DSM software will use air temperature as the basis for temperature set-points for the Actual, Notional, and Reference buildings.
c) Set back conditions for unoccupied periods
d) Sensible and latent heat gain from other sources;
e) Outside air requirement
f) Level of illuminance for general lighting and the power density for display lighting
g) Hot water demand

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[21] The NCM databases can be downloaded from www.uk-ncm.org.uk.

[22] In a school, these activities might be teaching classrooms, science laboratories, gymnasiums, eating areas, food preparation, staff room, circulation spaces or toilets. The parameter values vary between building types – e.g. offices in schools are not the same as those in office buildings.

h) Type of space for glazing, lighting and ventilation classification within Building Regulations compliance
i) A marker indicating whether the activity requires high efficiency filtration, thereby justifying an increased SFP allowance for that space to account for the increased pressure drop.

167 If there is not an activity in the database that reasonably matches the intended use of a space, then this should be raised with the database managers (see NCM website[21] for details) and an appropriate new activity proposed. This will be subject to peer review prior to formal acceptance into the database. Note that it is NOT acceptable for users to define and use their own activities. Consistent and auditable activity schedules are an important element of the compliance and certification processes and so only approved activity definitions can be used for these purposes[23]. If a special use space is present in the Actual building, and no appropriate activity is available in the database, it is accepted that time pressures may preclude waiting for the specific activity definition to be developed, peer reviewed and approved. In such situations, the energy assessor must select the closest match from the approved database. Because compliance and certification are both based on the performance of the Actual building to a Notional/Reference building, the impact of this approximation should be minimised.

Constructions

168 The thermal performance of construction elements must take account of thermal bridges:

a) Repeating thermal bridges must be included in the calculated plane element U-value as detailed in BR443. Simulation tools that use layer by layer definitions will need to adjust thicknesses of insulation layers to achieve the U-value that accounts for the repeating thermal bridges.
b) Non-repeating thermal bridges should be dealt with either by adding 10% to the standard area weighted average U-values, or by an equivalent method that satisfies BS EN ISO 14683, and be consistently applied to both Actual and Notional buildings.

169 Available on the NCM website is a database of calculated U-values etc, and for consistency, all implementations of the NCM should preferably use this database. It is accepted that a required construction may not always exist in the NCM database. In such cases, alternative sources of data may be used, but the person submitting for Building Regulations approval must declare this and demonstrate how the values were derived. The software tool must also highlight this alternative data source as part of the standard output.

170 When using the software tool to generate an EPC, the performance parameters for some constructions may not be known. In such situations, the parameters must be inferred based on the data provided in the NCM construction database. This is an important aspect of ensuring

[23] Clearly designers may wish to use alternative bespoke schedules for particular design assessments, but these exist outside the compliance/certification framework.

consistency in energy rating calculations, and so all software tools must adopt these procedures. This will be checked as part of the approvals process.

Low and zero carbon systems

171 The following approach must be followed when calculating the impact of on-site electrical generation for both Building Regulation calculations and EPCs as applied to non-dwellings.

a) Calculate the annual electrical energy used by the building irrespective of source of supply. Multiply that demand by the grid average CO_2 emission factor.
b) Calculate the electricity generated by the on-site system and multiply that by grid-displaced CO_2 emission factor, irrespective of the proportion of the electricity that is used on site and how much is exported.
c) The electricity related CO_2 emissions used to establish the BER is the net figure i.e. a) – b) above.
d) Any fuel used in generating the electricity (e.g. in a CHP engine) is added (at its appropriate CO_2 emission factor) to arrive at the total building CO_2 emissions.

Weather location

172 In order to calculate the reaction of the building and systems to the variable loads imposed by the external environment, the NCM needs an input of weather data. Standard weather sets have been adopted which must be used[24]. The available sites are

- Belfast
- Birmingham
- Cardiff
- Edinburgh
- Glasgow
- Leeds
- London
- Manchester
- Newcastle
- Norwich
- Nottingham
- Plymouth
- Southampton
- Swindon

173 The chosen weather data file should, in most circumstances be taken as the location from the above list which is closest in distance to the site of the proposed building. Where there are

[24] 2006 CIBSE Test Reference Years (see http://www.cibse.org)

particular micro-climate issues that need to be taken into account, one of the other 13 weather data files may be used if the weather data is more appropriate. It is for this reason that although this methodology is for England & Wales, additional UK weather sites have been included since in some cases they may provide a better representation of the climate in the locality of the Actual building. For example, if the proposed building was on Dartmoor, the nearest weather site would be Plymouth, but this has a much milder climate than on the nearby moors. Therefore a site with a climate that is more characteristic of an uplands site could be selected as being more appropriate. If the closest weather site is not used, the Regulation 17C compliance submission would need to justify the choice that has been made, but in all cases, one of the above sites must be selected.

Zoning rules

174 The way a building is subdivided into zones will influence the predictions of energy performance. Therefore this guide defines zoning rules that must be applied when assessing a building for the purposes of Building Regulations compliance or energy certification. The following procedure defines the approach to zoning for HVAC and lighting that must be followed.

175 The zoning arrangement must mimic the control strategy in the Actual building, and the same zoning arrangement must then be applied in the Notional building and Reference building. In the Actual building, zoning is defined by the extent of the control systems that modulate the output of the HVAC and lighting systems. Mapping the physical control zones into modelling zones should be the starting point for the zoning procedure. Any further adjustment to the zoning should only be:

a) As specified in the following general guidance (see paragraphs 178 to 180); or
b) Where specific limitations are imposed by the modelling tool that is being used (e.g. where a tool only permits each model zone to comprise one thermal zone and one lighting zone).

Zone types

176 A thermal zone is an area that:

a) Has the same heating and cooling set points; and
b) The same ventilation provisions; and
c) Has the same plant operating times; and
d) Has the same set-back conditions; and
e) Is served by the same type(s) of terminal device; and
f) Is served by the same primary plant; and
g) Where the output of each type of terminal device is controlled in a similar manner.

177 A lighting zone is an area that:

a) Has the same lighting requirement (levels and duration); and
b) Is served by the same type(s) of lamp/luminaire combination; and
c) Where the output of the lighting system is controlled in a similar manner.

d) Has similar access to daylight, i.e. the zone is bounded with fenestration having similar glazing ratio, light transmittance and orientation. This means that where benefit is being taken of daylight linked controls (manual or automatic) a given lighting zone must not extend beyond ~6 m from the perimeter.

178 For the purposes of modelling, a thermal zone can contain multiple lighting zones (e.g. daylight control at the perimeter with manual switching in the interior), but a lighting zone cannot extend across the boundary of a thermal zone. If this does occur in the Actual building, the relevant lighting zone must be subdivided into multiple smaller zones. The boundaries of these smaller zones are defined by the boundaries of the thermal zones.

Combining adjoining thermal zones

179 Adjoining thermal zones (horizontally or vertically) may be combined into a single larger zone provided that:

a) The zones are all the same in terms of the characteristics defined in paragraph 176 above.

b) The zones all have the same combination of activities inside them.

c) The zones have the same combination of lighting zones within them.

d) The zones all have the same exposure to the external environment in terms of glazing percentages, glazing types and orientation.

180 Where adjoining thermal zones are combined, then the partitions that separate the physical spaces must be included in the thermal zone in order to properly represent the thermal storage impact.

Fuel emission factors

181 The CO_2 emission factors for fuels will be as defined in **Table 24**.

Table 24 Fuel CO_2 emission factors for non-domestic buildings

Fuel type	$kgCO_2/kWh$
Natural gas	0.198
LPG	0.245
Biogas	0.018
Fuel oil	0.297
Coal	0.35
Anthracite	0.318
Manufactured smokeless fuel (inc. Coke)	0.344
Dual fuel appliances (mineral + wood)	0.206
Biomass	0.013
Grid supplied electricity	0.517
Grid displaced electricity	0.529
Waste heat	0.058

HVAC

182 For the Actual building, DSMs may represent HVAC systems explicitly, but will be required to report system seasonal performance parameters as an aid to checking – see paragraph 7c).

183 For DSM software that model HVAC with temperature control bands, the NCM activity cooling/heating set-points should be used as the mid-band point, and the control band should be ±0.5 K or less.

Lighting

184 Design lighting power densities should be adjusted to the appropriate NCM activity lighting level. *For example, an office with installed lighting load density of 10 W/m² that delivers 500 lux illuminance (i.e. 2 W/m² per 100 lux) would be adjusted to 8 W/m² for the purpose of compliance because the NCM activity assumes 400 lux illuminance.*

185 Lighting calculations for "As Designed" compliance checks should assume a space maintenance factor of 0.8, which corresponds to a clean space that is maintained every 3 years (*EN 12464*).

186 For Part L compliance, the lighting power density for activities such as storage warehouses and retail spaces which have racking/shelving, should be adjusted to ignore these elements (as the Notional building does not take these into account).

187 For Part L compliance, the lighting power density for activities which require special light fittings (e.g. intrinsically safe/anti-ligature luminaires) or where full spectrum daylight lamps are required (i.e. for medical purposes), should be adjusted to compensate for the de-rated output so that there is a fair comparison against the Notional building. Such adjustments need to be clearly documented and justified to Building Control.

Measurement and other conventions

188 In order to provide consistency of application, standard measurement conventions must be used. These apply to both DSMs and third party software interfaces to SBEM, although some parameters may only relate to the latter. These conventions are specified in Table 25 below:

Table 25 Measurement and other conventions

Parameter	Definition
Zone Area	Floor area of zone calculated using the internal horizontal dimensions between the internal surfaces of the external zone walls and half-way through the thickness of the internal zone walls. Used to multiply area-related parameters in databases. NB: If the zone has any virtual walls, the area of the zone is that delimited by the 'line' defining the virtual wall.
Envelope Area	Area of vertical envelopes (walls) = h × w, where: H = floor to floor height, i.e. including floor void, ceiling void and floor slab. For top floors, h is the height from floor to the average height of the structural ceiling. w = horizontal dimension of wall. Limits for that horizontal dimension are defined by type of adjacent walls. If the adjacent wall is external, the limit will be the internal side of the adjacent wall. If the adjacent wall is internal, the limit will be half-way through its thickness. NB: Areas of floor, ceilings, and flat roofs are calculated in the same manner as the zone area. Area for an exposed pitched roof (i.e. without an internal horizontal ceiling) will be the inner pitched surface area of the roof.
Window Area	Area of the structural opening in the wall/roof; the area therefore includes the area of glass + frame.
HWS Dead Leg Length	Length of the draw off pipe to the outlet in the space (only used for zones where the water is drawn off). Used to determine the additional volume of water to be heated because the cold water in the dead leg has to be drawn off before hot water is obtained. Assumes that HWS circulation maintains hot water up to the boundary of the zone, or that the pipe runs from circulation or storage vessel within the zone.
Flat Roof	Roof with pitch of 10 deg or less. If greater than 10 degrees, the roof is a pitched roof.
Pitched Roof	Roof with pitch greater than 10 deg and less than or equal to 70 deg - if the pitch is greater than 70 deg, it must be considered a wall.
Glazed door	When doors have more than 50% glazing, then the light/solar gain characteristics must be included in the calculation. This is achieved by defining these doors as windows.
Curtain walling	Glazed curtain walling systems should be modelled as glazing, where the spandrel area (i.e. non-vision areas) is accounted for in the frame factor.

APPENDIX D – EPBD RECAST

189 This section describes the modifications, to the calculation and output documents, required by the recast Energy Performance of Buildings Directive (EPBD2).

Primary energy consumption

190 A value for the total primary energy consumption by the Actual building will be calculated, based on the predicted delivered energy consumption for each fuel and the corresponding primary energy factors, as defined in **Table 26**, and will be reported in the BRUKL (compliance output document) summary.

Table 26 Fuel primary energy factors for non-domestic buildings

Fuel type	kWh/kWh
Natural gas	1.02
LPG	1.06
Biogas	1.10
Fuel oil	1.06
Coal	1.02
Anthracite	1.02
Manufactured smokeless fuel (inc. Coke)	1.08
Dual fuel appliances (mineral + wood)	1.04
Biomass	1.07
Grid supplied electricity	2.92
Grid displaced electricity	2.92
Waste heat	1.20

191 When calculating the building's primary energy consumption, any electrical energy generated by renewable technologies (principally PV systems and wind turbines) must be disregarded. Electrical energy generated by CHP generators will, however, be counted towards reductions in the primary energy use, i.e., the reported value for primary energy consumption will be net of any electrical energy displaced by CHP.

Alternative energy systems

192 Software tools will include additional questions for the user to confirm that the designers have considered in the new building design 'alternative energy systems', as defined in the recast EPBD (renewable energy systems, CHP, district heating/cooling, or heat pumps), and to confirm that there is documentary evidence of the feasibility assessment. They should also be asked if they have included any such systems in the proposed design solution. The answers to these questions will be reported in the BRUKL (compliance output document) summary.