























- 26 In addition, the U-values of display windows must be taken as 5.7 W/m<sup>2</sup>K in both the notional building and the actual building. Smoke vents and other ventilation openings such as intake and discharge grilles must be disregarded in both notional and actual buildings, and their area substituted by the relevant (ie immediately surrounding) opaque fabric (roof or wall).
- 27 Thermal bridge heat losses for each element (including windows etc) must be allowed for by adding 10 per cent to the standard U-values, or by an equivalent method that satisfies BS EN ISO 14683. Note that the U-values as given in Table 1 and the corresponding construction elements in the database DO NOT include this allowance, and so the calculation tool must make the adjustment explicitly.
- 28 Special considerations apply to ground floors, where the U-value is a function of the perimeter/area ratio. The following adjustments must be made<sup>4</sup>
- If the calculated value is greater than 0.25 W/m<sup>2</sup>K, the value of 0.25 W/m<sup>2</sup>K must be used in the notional building.
  - If the calculated value is less than 0.25 W/m<sup>2</sup>K with no added insulation, this lower value must be used in the notional building.
- 29 When modelling an extension, the boundary between the existing building and the extension must be disregarded (ie assume no heat transfer across it).
- 30 If using SBEM, the thermal capacity of the construction elements must be as defined in Table 2. Users of simulation tools must use the construction elements as given in the reference numbers in Table 1. The information in the database includes the necessary technical parameters to evaluate the impact of thermal capacity.

**Table 2: Thermal capacity of construction elements in the notional building**

Element	Effective thermal capacity (kJ/m <sup>2</sup> .K) **
External wall	11.7
Roof	12.0
Ground floor	36.0
Internal wall	11.9
Internal floor (and ceiling)	8.6

\*\* Effective thermal capacity is defined in prEN ISO 13790

- 31 The air permeability of the notional building must be 10m<sup>3</sup>/(h.m<sup>2</sup>) 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 notional, actual, reference and typical buildings. Acceptable methods include

<sup>4</sup> This follows the guidance given in CIBSE Guide A (2007)

- a) The method specified in the SBEM Technical Manual<sup>5</sup>, which is taken from EN 15242<sup>6</sup>.
- 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 of  $10\text{m}^3/(\text{h}\cdot\text{m}^2)$  at 50 Pa.

### Solar and daylight transmittance

- 32 In SBEM, total solar energy transmittance (g-value) of glazing and the daylight transmittance must be as given in the following table. These data apply to all windows, roof windows, rooflights and display windows. The data are based on a normal incidence value of 0.72 for solar transmittance and 0.76 for daylight transmittance. In order to limit overheating in the notional building, these factors are further adjusted so that the solar aperture is consistent with that specified in Table 4 of ADL2(2002). Appropriate values for intermediate orientations can be based on linear interpolation. Users of approved DSMs must use the glazing element as identified by the reference identifier in the glazing database.

*This variation in the solar and daylight transmittance with orientation is not an attempt to model varying daylight availability when using an overcast sky model. It is a pragmatic solution to achieving a building design that meets the heat loss requirements set out in Table 2 of ADL2(2002) and the avoiding solar overheating requirements set out in Table 4 of that same document.*

Table 3: Solar and daylight transmittances			
Orientation of glazing	Solar transmittance (g-value)	Daylight transmittance	Ref. ID in database
N	0.65	0.69	274
NE	0.65	0.69	276
E	0.52	0.55	277
SE	0.52	0.55	278
S	0.65	0.69	279
SW	0.52	0.55	280
W	0.52	0.55	281
NW	0.65	0.69	282
Horizontal	0.39	0.41	275

<sup>5</sup> SBEM Technical Manual Available at [http://www.ncm.bre.co.uk/files/SBEM\\_Technical\\_Manual.pdf](http://www.ncm.bre.co.uk/files/SBEM_Technical_Manual.pdf)

<sup>6</sup> Ventilation for buildings – Calculation methods for the determination of air flow rates in buildings including infiltration, EN 15242, CEN/TC 156, 2006

*Areas of windows, doors and rooflights*

- 33 The areas of windows, doors and rooflights 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 84.
- Subject to the following criteria, all external walls must have windows and all roofs must have rooflights.
  - Copy the areas of pedestrian doors, vehicle access doors and display windows that exist in the corresponding element of the actual building.
  - If the total area of these elements is less than the appropriate allowance from Table 4, the balance must be made up of windows or rooflights as appropriate.
  - If the total area of the copied elements exceeds the allowance from Table 4, the copied areas must be retained but no windows or rooflights added. As noted in paragraph 26, smoke vents and other ventilation openings must be ignored in both notional and actual buildings.
  - The areas as defined in Table 4 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 per cent (ie 90 per cent of the area of the opening is glazed) and rooflights a frame factor of 30 per cent.

**Table 4: Opening areas in the notional building**

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

- 34 In addition, the following rules apply:
- The notional building does not have any high usage entrance doors, even if these are present in the actual building.
  - In the notional building, pedestrian and vehicle access doors must be taken as being opaque, i.e. with zero glazing.
  - 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 4 percentages must apply to the above ground part, with zero glazing for the below ground part.

### **HVAC System definition**

- 35 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, ie:
- 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 an air conditioning system.
- 36 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, but it will be necessary to separately demonstrate that the space will not overheat following the guidance for compliance with criterion 3 in ADL2A (2006). 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. In this case it will also be necessary to separately demonstrate that the space will not overheat following the guidance for compliance with criterion 3 in ADL2A (2006).
- 37 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 DSMs<sup>7</sup>, the following modelling strategy must be used in the notional building. The strategy must increase the natural ventilation rate to 5 ach<sup>-1</sup> whenever the space temperature exceeds the heating set point<sup>8</sup> by 1K. This enhanced ventilation must cease immediately the space temperature falls below the heating setpoint.

*By maintaining the increased natural ventilation until internal temperatures fall to the (high) heating setpoint, the temperatures at start up next day will be neither artificially high or low.*

<sup>7</sup> 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.

<sup>8</sup> 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 setpoint in this context should be regarded as the temperature at the top of the proportional band, not its mid-point.

- 38 If the actual building includes humidity control, this must be ignored in both the notional and the actual building.
- 39 The following fuel must be used for heating and hot water services in the notional building:
- Where mains gas is used for space or water heating in the actual building, mains gas must also be used in the notional one. This means that if mains gas is used for heating but another fuel is used to supply hot water (or vice versa), then in the notional building gas must be used for both services on the basis that it is available.
  - Where mains gas is not used for either space or water heating in the actual building, Class D fuel oil must be used in the notional building unless the main heating fuel in the actual building is a low or zero carbon (LZC) heating technology when natural gas must be used in the notional building – see Table 5. Heat pumps should be regarded as being an LZC technology rather than being powered by electricity, since the majority of the heat delivered is recovered energy from ambient sources (air or ground). Similarly, waste heat should be taken as being an LZC technology irrespective of the fuel used to raise the heat in the first place.
  - For the purposes of this guide, the main heating fuel should be taken as the fuel which delivers the greatest total thermal output (space or water heating) over the year. If there are multiple devices served by the same fuel, the relevant total thermal output is the sum of all the outputs for the devices served by that fuel.

*Where the main heating fuel is a renewable fuel such as biomass, then gas is used in the notional building. To do otherwise would be to make the target too easy and potentially result in inefficient buildings being served by renewable fuels, thereby wasting renewable resources.*

**Table 5: Fuel type to be assumed in the notional building specification**

Main heating fuel in actual building	Fuel type in notional building
Natural gas	Natural gas
LPG	Class D fuel Oil
Oil	Class D fuel Oil
Coal	Class D fuel Oil
LZC heating technology (Biomass, biogas, heat pump, waste heat ...)	Natural gas
Grid supplied electricity	Class D fuel Oil
Anthracite	Class D fuel Oil
Smokeless fuel (inc coke)	Class D fuel Oil
Dual fuel appliances (mineral + wood)	Class D fuel Oil

- 40 The cooling and auxiliary energy must be taken to be powered by grid-supplied electricity.
- 41 The efficiency of the HVAC systems must be as given in Table 6. These figures have been selected to be consistent with the requirements of ADL2 (2002) as far as is practicable<sup>9</sup>.
- 42 The system performance definitions follow the practice set out in EN 15243<sup>10</sup>:
- 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<sup>11</sup>. Auxiliary energy demand must be calculated as detailed in paragraph 43 as appropriate.
  - b) Heating Seasonal Coefficient of Performance (SCoP) is the ratio of the sum of the heating demands 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 pipework, 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. Heating energy demand is therefore calculated from the following expression:

$$\text{Heating\_energy\_demand} = \frac{\sum \text{Zone\_annual\_heating\_load}}{\text{SCoP}}$$

- c) The Seasonal System Energy Efficiency Ratio for cooling (SSEER) is the ratio of the sum of the sensible cooling demands of all spaces served by a system to the energy content of the electricity (or fuel) supplied to chiller or other cold generator of the system. The SSEER includes, inter alia, chiller efficiency, heat gains to pipework 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

<sup>9</sup> Since the requirements were expressed in a different way in that document, a direct comparison is not possible.

<sup>10</sup> EN 15243, Ventilation for Buildings – Calculation of room temperatures and of load and energy for buildings with room conditioning systems, CEN, 2007

<sup>11</sup> Energy use in offices, Energy Consumption Guide 19, Action Energy, 2003



Technical Manual. Cooling energy demand is therefore calculated from the following expression

$$\text{Cooling\_energy\_demand} = \frac{\sum \text{Zone\_annual\_cooling\_load}}{\text{SSEER}}$$

**Table 6: HVAC Seasonal system efficiencies in the notional building**

Level of servicing	Cooling SSEER	Heating SCoP	Auxiliary Energy
1) Heating with natural ventilation	N/A	0.73	See para 43
2) Heated and mechanically ventilated	N/A	0.78	See para 43
3) Fully Air conditioned	1.67	0.83	See para 43
4) Changeover mixed mode	2.25	The relevant SCoP value from row 1 or 2 above, depending on the form of ventilation	See para 42: use the relevant value depending on the form of ventilation
5) Unheated and naturally ventilated	N/A	N/A	0

- 43 The auxiliary energy per unit floor area must be calculated as follows:
- a) For heated only spaces: the product of 0.61 W/m<sup>2</sup> and the annual hours of operation of the heating system from the activity database.
  - b) For mechanically ventilated spaces: the product of the outside air rate for the space, the annual hours of operation (both from the activity database) and the appropriate specific fan power from Table 7.
  - c) For air-conditioned spaces: the product of the annual hours of operation times the greater of:
    - i) the product of the fresh air rate and the appropriate SFP from Table 7 and
    - ii) 8.5W/m<sup>2</sup>.

**Table 7: Specific fan power for different ventilation systems**

System type	Specific fan power W/l s <sup>-1</sup>
Centralised balanced mechanical ventilation system, including the air supplies to centralised air conditioning systems	2.0**
Zonal supply system where the fan is remote from the zone, such as ceiling void or roof mounted units	1.2**
Zonal extract system where the fan is remote from the zone	0.8
Local ventilation-only units, such as window/wall/roof units serving a single area (eg toilet extract)	0.5
** If the activity in the space requires the use of higher levels of filtration (e.g. HEPA filters – see paragraph 69i)), then the specific fan power must be increased by 1.0 W/l s <sup>-1</sup> .	

- 44 In the notional building
- No allowance should be made for heat recovery equipment.
  - No allowance should be made for demand control of ventilation.
- 45 HWS overall system efficiency (including generation and distribution) must be taken as 45 per cent with the same fuel as that assumed for heating – see paragraph 39. 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/(m<sup>2</sup>.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.
- 46 The notional building must be assumed to have no power factor correction or automatic monitoring and targeting with alarms for out of range values, ie none of the adjustment factors from ADL2A(2006) Table 3 apply.

### ***Installed lighting power density in the Notional Building***

- 47 For general lighting:
- 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/m<sup>2</sup> per 100 lux. This includes all spaces that accommodate predominantly office tasks, including classrooms, seminar rooms and conference rooms, including those in schools.
  - for other spaces, divide the illuminance appropriate to the activity in the space by 100, then multiply by 5.2 W/m<sup>2</sup> per 100 lux.
- 48 For display lighting, take the notional display lighting density appropriate to the activity from the activity parameter database.
- 49 In all cases, the duration of the lighting demand must be as per the activity schedule in the NCM database.

- 50 It must be assumed that the general lighting in the notional building has local manual switching in all spaces.

*Calculation methods for the impact of controls on lighting energy demand must be at least as detailed as the procedure specified in the SBEM Technical Manual<sup>5</sup>.*

### **The Target Emission Rate (TER)**

- 51 The notional building with the parameters as defined above must be used as the basis of determining the carbon dioxide emission target (the TER), irrespective of the calculation method used to determine the heating and cooling demands themselves. For the actual building, DSMs may represent HVAC systems explicitly, but will be required to report overall seasonal performance parameters as an aid to checking – see paragraph 7c).
- 52 The TER must then be calculated by adjusting the emissions of the notional building and reducing them by an improvement factor as outlined in paragraph 23 of ADL2A (2006). The level of improvement for buildings with different classes of building services,  $IF_b$ , is calculated applying the relevant improvement factor, ( $IF_i$ ), to each area of the building with different servicing strategies weighted by the  $CO_2$  emissions of that area from the notional building ( $kgCO_{2,i}$ )

$$IF_b = \text{SUM}(IF_i * kgCO_{2,i}) / \text{SUM}(kgCO_{2,i})$$

Where:

$IF_i$  represents the improvement factors from Table 1, column (a) of ADL2A that applies to area  $i$  of the building. If the area is designed for mixed-mode operation, then the improvement factor for heated and naturally ventilated space must be used.

$kgCO_{2,i}$  is the kg carbon dioxide emissions from the notional building produced in area  $i$ , where  $i$  refers to each area of the building that has a different servicing strategy.

## Energy Performance Certificates

- 53 This section of the manual defines the reference and typical buildings, which are 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.
- 54 EPCs are intended to send market signals about the relative performance of comparable buildings, and so it is necessary that the reference building

must be the same for all buildings of a given type. In order to provide this consistency, the reference building must be the same irrespective of:

- a) whether the building is naturally ventilated or air conditioned.
- b) the fuel choice.

### Detailed definition of the Reference building for buildings other than dwellings

- 55 The insulation levels and HVAC efficiencies in the reference building are identical to the Part L notional building defined above except that certain parameters in the reference building are fixed irrespective of features in the actual building (see paragraph 54). These aspects are given below. Unless specified as being different, all other parameters must be taken as per the notional building definition given in the preceding section of this guide.
- a) The heating and hot water service is always met by a gas-fired system irrespective of whether a fuel other than gas is used in the actual building, or is even available in the locality of the actual building.
  - b) The reference building has a fixed servicing strategy regardless of the strategy adopted in the existing building. Therefore:
    - i) Each space is heated as defined by the heating setpoints defined in the activity database. The heating SCoP and auxiliary energy must be taken to be the same as for heating only case in the notional building (see Table 6).
    - ii) Each space is cooled, with the cooling setpoint fixed at 27°C irrespective of whether the particular space in the actual building has cooling provision or not<sup>12</sup>. 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).

*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) rather than the Design Summer Year basis that is used for criterion 3 (Limiting the effects of solar gain in summer) in Part L.*

- 56 The CO<sub>2</sub> 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<sub>2</sub> emissions in the actual building. This adjusted CO<sub>2</sub> emissions rate is termed the Standard Emission Rate (SER). This

<sup>12</sup> If the space in the actual building has cooling system, then the calculation of the performance of the actual building will be assessed by cooling the space to the cooling setpoint temperature as defined in the activity database. User specified cooling setpoints are not allowed.

means that a gas heated mixed-mode building that is just compliant with Part L (2006) would have an Asset Rating of 100. When making the adjustment, the improvement factor must be taken as 23.5 per cent. In summary

$$\text{SER} = \text{RER} * 0.765$$

*This is the overall improvement required for a heated and naturally ventilated building, compared to 28 per cent for a mechanically ventilated or air-conditioned building as given in ADL2A. 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. Further, if the building is air conditioned to normal standards, the reference building will already have a lower energy demand than the Part L notional building, because it is not cooled to the same extent (27°C for mixed mode compared to typically 22-24°C for air conditioning). This will compensate (to some extent) the smaller improvement factor compared to that required by Part L.*

- 57 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.

### Calculating the Asset rating

- 58 The Asset Rating is the ratio of the CO<sub>2</sub> emissions from the actual building (ie the BER) to the Standard Emission Rate, SER, with the result normalised such that the SER is equivalent to an Asset Rating of 50, ie  $\text{AR} = 50 * \text{BER} / \text{SER}$ . The calculated AR must be rounded to the nearest whole number, ie 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

- 59 The A to G scale is a linear scale based on two key points defined as follows:
- The zero point on the scale is defined as the performance of the building that has zero net annual CO<sub>2</sub> 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.
  - 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 and benchmarks

- 60 The EPC 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 (ie the TER). Note this is based on the performance of the notional building, not the reference building.
- b) The performance of a typical building. The typical performance is based on the 1995 Part L standards. The relevant performance parameters are specified in Appendix A

## Modelling the actual building

### *The impact of thermal comfort on CO<sub>2</sub> emissions*

- 61 In order to provide a consistent assessment of the asset rating, the calculation procedure must always control the space temperature to the set-point defined for the relevant activity area in the NCM database, irrespective of the control temperature prevailing in the building as it operates in practice. The control set point will only vary according to the level of servicing provided, ie no cooling, mixed mode or full air conditioning.
- 62 In buildings without mechanical cooling the level of thermal comfort achieved will vary during the summer months and will differ from building to building. Consequently, the degree of overheating must be reported via the recommendations report, with the EPC just being based on the systems actually installed in the building. This approach is more factually correct, and allows the incoming occupier to assess whether the overheating risk is significant or not in terms of the intended use of the space.

*Overheating risk analysis has only been included in Part L since the 2002 changes, and so there has been no formal assessment of the summer performance of the vast majority of existing buildings, many of which have much higher internal gains than when first designed, and where overheating may be a significant problem. Consequently it would be possible for a building to have a better EPC rating than another, but once occupied, the new owner/tenant might find it necessary to install cooling. Hence the requirement to include an overheating assessment as part of the recommendations report.*

- 63 The degree of overheating must be reported as follows, with the overheating threshold temperature set at an operative temperature of 27°C.

*The results of this automated analysis are only approximate, and so it is recommended that potential occupiers and their advisors consider carrying out a specific risk assessment based on the intended use of the space and appropriate weather data, which might include estimates of the impact of future global warming.*

**Table 8: Definition of overheating criteria**

	(a) SBEM	(b) DSMs
Criterion	Ratio ( $R_k$ ) of cooling demand for temperature of 27°C to that at cooling setpoint in activity database	per cent occupied hours ( $\theta$ ) exceeding 27°C operative temperature
Low risk	$R_k < 0.15$	$\theta < 0.5$ per cent
Moderate risk	$0.15 \leq R_k < 0.30$	$0.5 \text{ per cent} \leq \theta < 1$
Significant risk	$0.30 \leq R_k < 0.50$	$1 \text{ per cent} \leq \theta < 1.5 \text{ per cent}$
High risk	$R_k \geq 0.50$	$\theta \geq 1.5 \text{ per cent}$

64 This assessment is only required for naturally ventilated spaces, since air conditioned and mixed mode zones will have cooling capacity to prevent overheating. The assessment must be made on a zone by zone basis. For the DSM criterion as set out in column (b) of Table 8, the occupied period should be taken as those hours where the occupancy is greater than 20 per cent of the peak occupancy level.

65 In a similar way, there will be diversity in the existing building stock over the ventilation rate, since the minimum rate defined in Building regulations has changed over the years. To provide a consistent assessment of energy performance, all calculations must be based on the outdoor air rate currently specified in ADF as the minimum for non-domestic buildings, ie 10l/(s. person).

*Given the importance of ventilation heat loss, and of fan energy, differences in ventilation provision could be significant when rating buildings. If different ventilation rates were used, a building designed to ADF(2006) could have a worse energy rating than one designed pre-2006, even though it is intrinsically more efficient.*

## Input data to approved tools

66 This section describes generally applicable approaches to data input and modelling strategies, and applies equally to Part L compliance and EPCs, and also to the modelling of notional, actual reference and typical buildings.

### Defining internal gains and environmental conditions

67 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<sup>13</sup>. One of these standard activities must be assigned to each space in the building<sup>14</sup>.

<sup>13</sup> The NCM databases can be downloaded from <http://www.ncm.bre.co.uk>

<sup>14</sup> In a school, these activities might be teaching classrooms, science laboratories, a gymnasium, eating areas, food preparation, staff room, circulation spaces or toilets. The parameter values vary between building types – eg offices in schools are not the same as those in office buildings.



- 68 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.
- 69 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; users are free to decide whether the temperature setpoint is based on operative<sup>15</sup> or air temperature, provided the same index is used when calculating the energy performance of both the notional and actual buildings.
  - c) Set back conditions for unoccupied periods
  - d) Sensible and latent heat gain from other sources
  - e) Outside air requirement
  - f) Fixed and portable lighting requirement, including display lighting
  - g) Hot water demand
  - 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.
- 70 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<sup>13</sup> 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<sup>16</sup>. 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.

<sup>15</sup> Operative temperature is the CIBSE preferred comfort index and is approximated in most situations by the mean of the air and mean radiant temperatures.

<sup>16</sup> Clearly designers may wish to use alternative bespoke schedules for particular design assessments, but these exist outside the compliance/certification framework.



## Constructions and plant components

- 71 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, excluding paragraph 3.10.2 which is currently not to be used, or the current editions of international standards to which ADL2(2002) refers. 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) Thermal bridges at junctions and around openings as described in IP 1/06.
- 72 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.
- 73 When using the software tool to generate an EPC, the performance parameters for some constructions and some plant components may not be known. In such situations, the parameters must be inferred using the procedures set out in the SBEM Technical Manual <sup>5</sup>.

*This is an important aspect of ensuring 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

- 74 The following approach must be followed when calculating the impact of on-site electrical generation for both Part L 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<sub>2</sub> emission factor.
  - b) Calculate the electricity generated by the on-site system and multiply that by grid-displaced CO<sub>2</sub> emission factor, irrespective of the proportion of the electricity that is used on site and how much is exported.
  - c) The electricity related CO<sub>2</sub> emissions used to establish the BER is the net figure ie a) – b) above.
  - d) Any fuel used in generating the electricity (eg in a CHP engine) is added (at its appropriate CO<sub>2</sub> emission factor) to arrive at the total building CO<sub>2</sub> emissions.

## Weather location

- 75 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<sup>17</sup>. The available sites are
- a) Belfast
  - b) Birmingham
  - c) Cardiff
  - d) Edinburgh
  - e) Glasgow
  - f) Leeds
  - g) London
  - h) Manchester
  - i) Newcastle
  - j) Norwich
  - k) Nottingham
  - l) Plymouth
  - m) Southampton
  - n) Swindon
- 76 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 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

- 77 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

<sup>17</sup> These are the 2006 CIBSE Test Reference Years see <http://www.cibse.org/index.cfm?go=publications.view&item=332>. Monthly average files have been created for use with SBEM.

compliance or energy certification. The following procedure defines the approach to zoning for HVAC and lighting that must be followed.

- 78 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, the reference building and the typical 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 81 and 82); or
  - b) where specific limitations are imposed by the modelling tool that is being used (eg where a tool only permits each model zone to comprise one thermal zone and one lighting zone).

### **Zone types**

- 79 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.
- 80 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, ie 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 ~6m from the perimeter.
- 81 For the purposes of modelling, a thermal zone can contain multiple lighting zones (eg 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***

- 82 Adjoining thermal zones (horizontally or vertically) may be combined into a single larger zone<sup>18</sup> provided that:
- a) The zones are all the same in terms of the characteristics defined in paragraph 79 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.
- 83 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.

### **Measurement and other conventions**

- 84 In order to provide consistency of application, standard measurement conventions must be used. These apply to both DSIMs and third party software interfaces to SBEM, although some parameters may only relate to the latter. These conventions are specified in Table 9 below:

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<sup>18</sup> This allows (e.g.) identical hotel bedrooms along a façade to be lumped into a single zone.

**Table 9: Measurement and other conventions**

Parameter	Definition
Zone Area	<p>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.</p> <p>NB: If the zone has any virtual walls, the area of the zone is that delimited by the 'line' defining the virtual wall.</p>
(Building) Total Floor Area	Sum of zone areas. Used to check that all zones have been entered by comparing this figure with the Total Useful Floor Area declared for the building.
Envelope Area	<p>Area of vertical envelopes (walls) = <math>h * w</math>, where:</p> <p><math>h</math> = floor to floor height, ie including floor void, ceiling void and floor slab. For top floors, <math>h</math> is the height from floor to the average height of the structural ceiling.</p> <p><math>w</math> = 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.</p> <p>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.</p>
Window Area	Area of the structural opening in the wall/roof; the area therefore includes the area of glass + frame. Percentage glazing is based on the area of wall seen from inside the zone looking out, and therefore excludes the wall area taken up by floor/ceiling voids, floor slabs etc.
HWS deadleg Length	Length of the drawoff 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 deadleg 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 20 deg and less than or equal to 70 deg – if the pitch is greater than 70 deg, it must be considered a wall.
Display Window	As defined in ADL2A.
Personnel Door	As defined in ADL2A.
High Usage Entrance Door	As defined in ADL2A.
Vehicle Access Door	As defined in ADL2A.
Glazed door	When doors have more than 50 per cent glazing, then the light/solar gain characteristics must be included in the calculation. This is achieved by defining these doors as windows.

# Appendix A – parameters for the typical building

- 85 The typical building is identical to the reference building apart from the parameters set out below. Unless specified as being different, all other parameters must be taken as per the reference building as defined given in the earlier section of this guide.
- 86 U-values/construction types must be as given in the following table.

Exposed element	U-value (W/m <sup>2</sup> K)	Database reference IDs
Roofs <sup>1</sup> (irrespective of pitch)	0.50	370
Walls	0.45	303
Floors and ground floors (subject to the same logic as set out in paragraph 28)	0.45	105
Windows, roof windows, rooflights, curtain walling and pedestrian doors <sup>2</sup>	3.9	244
Vehicle access and similar large doors	1.5	240
Internal walls	2.0	307
Internal window	3.85	284
Internal floors (viewed from room above)	1.25	365
Internal floors (viewed from room below)	1.23	315

<sup>1</sup> Any part of a roof having a pitch greater or equal to 70° is considered as a wall

<sup>2</sup> This U-value 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 .

- 87 Solar and light transmittances must be as per the notional building, but the U-value should be as given above. The variation of solar and light transmittance should be as per Table 3, although the reference ID in the database will change to account for the changed U-value. The sequence of reference IDs follows Table 3 except that the number is 3nn rather than 2nn, ie south facing glazing in the typical building should use reference ID 379 (compared to 279 in the notional building).
- 88 The air permeability must be taken as 15 m<sup>3</sup>/(h.m<sup>2</sup>) at 50Pa.
- 89 The HVAC system seasonal efficiencies must be as given in the following table.

**Table 11: HVAC Seasonal system efficiencies in the typical building**

Level of servicing	Cooling SSEER	Heating SCoP	Auxiliary Energy
1) Heating with natural ventilation	N/A	0.55	See para 90a)
2) Heated and mechanically ventilated	N/A	0.55	See para 90b)
3) Fully Air conditioned	1.17	0.55	See para 90c)
4) Changeover mixed mode	1.9	The relevant SCoP value from row 1 or 2 above, depending on the form of ventilation	See para 90: use the relevant value depending on the form of ventilation
5) Unheated and naturally ventilated	N/A	N/A	0

90 The auxiliary energy per unit floor area must be calculated as follows:

- a) For heated only spaces: the product of  $1.23 \text{ W/m}^2$  and the annual hours of operation of the heating system from the activity database.
- b) For mechanically ventilated spaces: the product of the outside air rate for the space, the annual hours of operation (both from the activity database) and the appropriate specific fan power from Table 12.
- c) For air-conditioned spaces: the product of the annual hours of operation and the greater of:
  - i) the product of the fresh air rate and the appropriate SFP from and Table 12.
  - ii)  $14.0 \text{ W/m}^2$ .

**Table 12: Specific fan power for different ventilation systems**

System type	Specific fan power $\text{W/ls}^{-1}$
Centralised balanced mechanical ventilation system, including the air supplies to centralised air conditioning systems	3.0**
Zonal supply system where the fan is remote from the zone, such as ceiling void or roof mounted units	1.8**
Zonal extract system where the fan is remote from the zone	1.1
Local ventilation-only units, such as window/wall/roof units serving a single area (e.g. toilet extract)	0.75

\*\* If the activity in the space requires the use of higher levels of filtration (eg HEPA filters – see paragraph 69i)), then the specific fan power must be increased by  $1.0 \text{ W/ls}^{-1}$ .

91 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  $4.5 \text{ W/m}^2$  per 100 lux. This includes all spaces that involve 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, then multiply by  $6.2 \text{ W/m}^2$  per 100 lux.

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