National Association of Rooflight Manufacturers

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Designing with Rooflights

Supporting Part L Building Regulation guidance in England; Approved Documents L1A, L1B, L2A and L2B (2013 editions)

CONTENTS

SCOPE

- This document gives guidance on the use of natural daylight via rooflights to provide compliance with Building Regulations L1 and L2 2010 - Conservation of Fuel and Power for Dwellings and Buildings other than Dwellings -as amended in 2013

- This document only applies to England. Technical Document F in Northern Ireland has a similar basis to England. Scotland have their own Regulations under section 6 - they require a 43% reduction in emissions for non-domestic buildings from October 2015, but the documents are not available until November 2014. Wales, for the first time has moved away from the England Regulations, for non-domestic aiming for a greater reduction in CO_2 emissions c.f. Part L 2010. Extensions will require improvements to walls and roofs, but windows remain unchanged. The Welsh Regulations come into effect in July 2014.

- This document covers both Approved Document L2A (ADL2A) which applies to New Work for non-domestic buildings, Approved Document L2B (ADL2B) - Repairs, Refurbishment and Extensions to non-domestic buildings, and for the first time NARM have included comment on Part L1A & B for Domestic Buildings.

- Note that large extensions to existing buildings, where the total floor area of the extension is greater than 100m^2 and greater than 25% of the total floor area of the existing building, are treated in the same way as new build and fall under the control of AD L2A.

- Note that Dwellings relate to self contained units only. However, buildings exclusively containing Rooms for Residential Purposes such as nursing homes, and student accommodation or similar, are not considered as dwellings and therefore such buildings come under the control of ADL2

- Buildings that fall outside the requirements of Part L, e.g. unheated agricultural buildings, are not covered by this document. Industrial sites, workshops and agricultural buildings with low energy demand for heating or cooling are exempt from the Part L Regulations. Note that warehouses (for example) with a low energy demand are not exempt since they are not buildings in the exempt category.

- Note that such buildings, with low energy demand that are not exempt, may be built with less demanding requirements. However, be aware that a subsequent change of use for the building may require the building to be upgraded to fully meet AD L2A requirements and such a fit out could be far more expensive than complying with AD L2A at the new build stage – (refer to AD L2A para 2.24 to 2.27)

- This document does not give guidance on the use of vertical windows

- It does not give guidance on matters that have no bearing on the use, effect and control on natural daylighting into buildings

- Reference will be made to the Simplified Building Energy Model (SBEM) software which is a free-of-charge approved calculation tool referenced by AD L2A Section 2.3a to determine building compliance, including guidance on how various rooflight systems should be entered into SBEM. All results shown have been calculated using SBEM v5.2.b. For AD L1A, the approved complaint software is Standard Assessment Procedure (SAP) which is referred to in this document for dwellings. This document does not cover other approved software tools.

- Reference will also be made to the National Calculation Methodology modelling guide (NCM) which provides the data that is embedded within SBEM.

- This document provides background information on the research carried out by De Montfort University (DMU) into the impact of rooflights on the overall energy demand and the associated carbon dioxide (CO_2) emissions. It shows that as rooflight area is increased up to 20% of the floor area, CO_2 emissions will generally decrease as the contribution of natural daylight through rooflights replaces the need for artificial lighting.

- Via examples using SBEM, this document will demonstrate the need to consider the total lighting demand for a building and to use light saving devices for all installed artificial lighting.

- It does not make any recommendation on the types of artificial lighting or lighting control that may be used to supplement the natural daylight provided by rooflighting.

INTRODUCTION

All reference to the changes to ADL1A & B will be found on pages 21-26 of this document. The following refers to the changes relating to Non-Domestic Buildings.

The Building Regulations Part L 2013, designed to save energy and power consumption in buildings, is the latest phase of an ongoing legislative programme by Government with further updates planned over the next 6 years to create a long term building stock that will generate an ever decreasing release of CO_2 into the atmosphere. The Regulations came into effect on 1st April 2014.

The Key Changes to Part L2A 2013 c.f. Part L2A 2010.

1. For non-domestic buildings there is a need to deliver an aggregate uplift of 9% saving in carbon emissions with elemental back stops.

2. In the 2010 Regulations, Criterion 2 recommended a limit on design flexibility with worst case “U” values for the fabric elements of the building. Criterion 2 2013 now makes it a Statutory requirement to comply with these limiting Fabric Parameters, as shown in AD L2A Table 3 (see note 1.4 of ADL2A). For rooflights this is a U value of 2.2W/m2K.

3. The Notional Building used to determine CO_2 targets remains the same size and shape as the actual building, and is still separately defined for top-lit, side-lit and side-lit (air conditioned) buildings). The Notional Building air permeability has been further sub divided by size.

4. A summary of the Part L2A 2013 Notional Buildings is now published in Table 5 of the ADL2A , with full details defined in the National Calculation Modelling (NCM) Guide. If the actual building is constructed entirely to the notional building specification, it will meet the CO_2 targets and the limiting fabric and service parameters.

It is clear that the statutory minimum requirements for the fabric of the building as stated in Table 3 are fall back values. In practice to achieve the Target Emission Rate (TER) for the building, some or all of the fabric limits will need to be improved. Designers and builders will need to look at every element of the design and services of their building and seek to achieve performance improvements over the fall back requirements and be guided by the figures used in the Notional Building in Table 5 ADL2A.

DESIGNING WITH ROOFLIGHTS TO SAVE ENERGY

Independent research carried out in 2005 by De Montfort University proved conclusively that rooflights save energy. A well designed building with a good spread of natural light will benefit from passive solar gain and a reduced requirement for artificial light. The combination of these factors means that including rooflights can offer a dramatic reduction in a building's total energy consumption and the emissions of CO_2 associated with this energy use. These conclusions are reflected in SBEM. A naturally lit interior will save money, provide a more pleasant environment people want to spend time in and contribute to the government's target to reduce emissions of CO_2.

The primary reason for including rooflights is to provide a bright, naturally lit interior and reduce the requirement for artificial lighting. Daylight has many advantages over artificial light - not least the fact that it is a completely free, unlimited natural resource. Whilst artificial light is essential, it's provision uses a lot of energy, so reducing the requirement will dramatically cut energy use, and the CO_2 emissions which result from this.

There has previously been a widely held view that whilst rooflights are an excellent way of bringing the many benefits of natural light into a building, their poorer insulation value allowed more heat to escape than the rest of the roof structure, increasing the running costs of the building. Research over a number of years has confirmed this view is wrong.

Increased rooflight area can dramatically reduce the energy requirements of lighting systems whilst resulting in a much smaller increase in energy requirements of the heating system, but the relative effects depend on a number of other parameters for the building, such as temperature set point, hours of occupancy, and internal gains, as well as the details of the building construction. The savings in total energy costs and carbon footprint therefore vary from building to building, but are usually found to be positive as rooflight area increases often up to 20% of the roof area for large buildings with internal work height greater than 6m and up to 15% rooflight area for buildings of lower than 6m work height.

The Institute of Energy & Sustainable Development at Leicester's De Montfort University (DMU) have investigated the effect that rooflights have on the total energy needed to operate a building, and the annual CO_2 emissions which result from this. The research proved that installing an appropriate level of rooflighting (typically 15% - 20% of the roof area) will usually reduce overall energy consumption, and the associated CO_2 emissions, in addition to providing the widely recognised benefits of natural daylight within a building environment. Their work is summarised in Appendix 2 of this publication.

The Simplified Building Energy Method (SBEM), the free-of-charge computer modelling package used to demonstrate compliance with Part L2A Building Regulations, uses the same principles as the DMU research, and so also recognises the contribution to energy saving and reduction in CO_2 emissions which are offered by the inclusion of high levels of rooflights.

Many factors affect the contribution which rooflights can make, and hence the optimum area of rooflights will vary from building to building. However, in general, the conclusions of the DMU work (reflected in results from SBEM) show that rooflights always make a positive contribution: omission of rooflights or reduction of rooflight area gives a very significant increase in CO_2 emissions, and that savings offered by rooflights are dramatic:

- Typically the total CO_2 emissions associated with all aspects of operating a building without rooflights can be over 50% higher than for a building with 12% rooflights

- in almost all relevant buildings, savings continue to be achieved as rooflight area is increased up to and beyond 15% of floor area

- in some buildings (typically with higher illumination requirements, and used predominantly during the daytime) there are significant further savings as rooflight area increases up to 20% at higher illumination levels

- in other buildings (typically with lower illumination requirements, and used 24 hours a day) the savings as rooflight area is increased from 12% to 15% are relatively minor, with very slight increases in CO_2 emissions as area increases further, to 20%

- Rooflight area of 15% or more of floor area may therefore be a useful approximation of the optimum rooflight area.

- Care should be taken to avoid risk of solar overheating (see guidance on ADL2A Criterion 3, page 11): typically, rooflight area should be limited to 18-20% of floor area in buildings over 6 metres tall, and 12-13% of floor area in buildings less than 6 metres tall.

ARTIFICIAL LIGHTING CONTROLS

Designers need to recognise that artificial lighting will be essential during parts of the working day and particularly in the winter months, and specifically in working areas where light levels need to remain constant. In order to minimise the use of artificial lighting, thereby maximising the energy savings from natural daylight, artificial lighting should be, where ever possible controlled by automatic means that operate on "need" requirements.

Designers need to bear in mind these key points :-

- The electric light is carbon inefficient in that power from the National Grid is largely generated from burning fossil fuel at modest generation efficiencies.

- Where natural daylight levels are low, without lighting control, the lights in the work place get turned on in the morning and stay on all day, regardless of the need for them.

- Natural daylight through rooflights is completely free, provides some useful solar gain and makes the work place a more pleasant environment.

There are specific changes/requirements relating to artificial lighting that are now built into the Notional Building used by SBEM:

1. General lighting will have efficacy of 60 luminaire lumens/circuit watt.

2. All zones which receive natural daylight will incorporate photo-electric dimming.

3. All zones will incorporate "manual on – auto off" occupancy sensing systems.

This document does not detail all the options that are available, however a Joint Document from NARM and the Lighting Industry Federation (LIF) called "**Designing with Rooflights and Controlled Artificial Lighting to reduce CO_2 emissions – supporting the requirements of the Building Regs Part L2A & L2B**" is available on the NARM web site www.narm.org.uk

AD L2A NEW BUILDINGS OTHER THAN DWELLINGS

General Comment
The 2013 Regulations require a delivery of a further 9% aggregated saving across the mix of non-domestic buildings c.f. AD L2A 2010. The building type savings are given below:

Distribution Warehouse	4%
Deep Plan Office with Air Conditioning	12%
Retail Warehouse	8%
Shallow Plan Office	13%
Hotel	12%
School	9%
Small Warehouse	3%
Aggregate value	**9%**

These savings will be built into the National Calculation Model for the building type which is used in SBEM.

The concept is that designers and builders are free to design and build, provided the CO_2 emissions of the actual building as calculated by SBEM (the BER) are no more than the emissions of a notional building of the same size and type (the TER):

Building Emission Rate (BER) ≤ TER

It should be noted that unless high standards of specification and build are maintained throughout, compliance will be difficult to achieve. The limiting Fabric Standards in Criterion 2 are now a Statutory requirement, but to achieve the TER, it is likely that there will be a need to improve the performance of the Limiting Standards.

5 CRITERIA

AD L2A defines 5 Criteria to achieve Compliance:

Criterion 1 : Achieving the TER

Criterion 2 : Limits on Design Flexibility

Criterion 3 : Limiting the effect of heat gains in summer

Criterion 4 : Building performance consistent with the BER

Criterion 5 : Provisions for energy efficient operations of the building (this is not covered in this document)

Note that:

- Criterion 1 is a regulation and therefore mandatory
- Criterion 2 is Statutory Guidance
- Criteria 3, 4 and 5 are for guidance.

CRITERION 1 ACHIEVING THE TER

Target (CO_2) Emission Rate (TER)
The TER is the maximum CO_2 emission rate that is allowable for any new building. It is expressed in terms of the mass of CO_2 emitted per year per sq. metre of the total useful floor area of the building (kg/m^2/year).

The TER is calculated for a Notional Building of the same size, shape, location, orientation, and usage as the actual building, but with performance of fabric, services and controls all as defined in AD L2A and the NCM Modelling Guide.

Building Emission Rate (BER)
The BER is the CO_2 emission rate for the actual building, calculated in exactly the same way as the TER but based on the properties (fabric, servies and controls) of the actual rather than Notional Building.

All the data for the actual building (geometry and full details of the building fabric and building services) are entered into SBEM which calculates and compares the BER and the TER. If the BER ≤ TER then the building is compliant.

It is mandatory that the BER is less than or equal to the TER. How rooflights can be best used to help achieve this is explained in this document and demonstrated in Appendix 1.

Notional Building Specification
SBEM uses one of 3 different Notional Building types:

a. Side lit or unlit (with heating only)

b. Side lit or unlit (with heating and cooling)

c. Top lit

The specification of each Notional Building is detailed within the NCM Modelling Guide, and summarised in AD L2A Table 5 (see ADL2A page 27), an extract of which is shown below. For all rooflit areas, the specification includes:

- 12% rooflight area
- Rooflight U-value 1.8 W/m^{2}K
- Rooflights with 60% light transmission, 55% G-value and 15% frame factor
- Proportional (dimming) control of all artificial lighting systems, with parasitic power that is the lesser of either 3% of the installed lighting load, or 0.3W/m^2

If the actual building has a rooflight area of 12%, and all other values match those in Table 5 (as summarised below), then the SBEM calculation for the actual building will exactly match that for the notional building, BER=TER, and the building will achieve compliance.

Note that the illumination provided by rooflights is defined by the product of:

Area x light transmission
x glazed area (i.e. 1 –frame factor)

which for the notional building is:

12% x 60% x (1-15%) = 12% x 60% x 85%
= 0.0612.

Designers can amend individual values and buildings will remain compliant, provided this overall value is not reduced: for example, if actual rooflight transmission is 54%, frame factor is 12% and rooflight area is 13%, then this value is not reduced:

13% x 54% x (1-12%) = 13% x 54% x 88%
= 0.0618 ie ≥0.0612

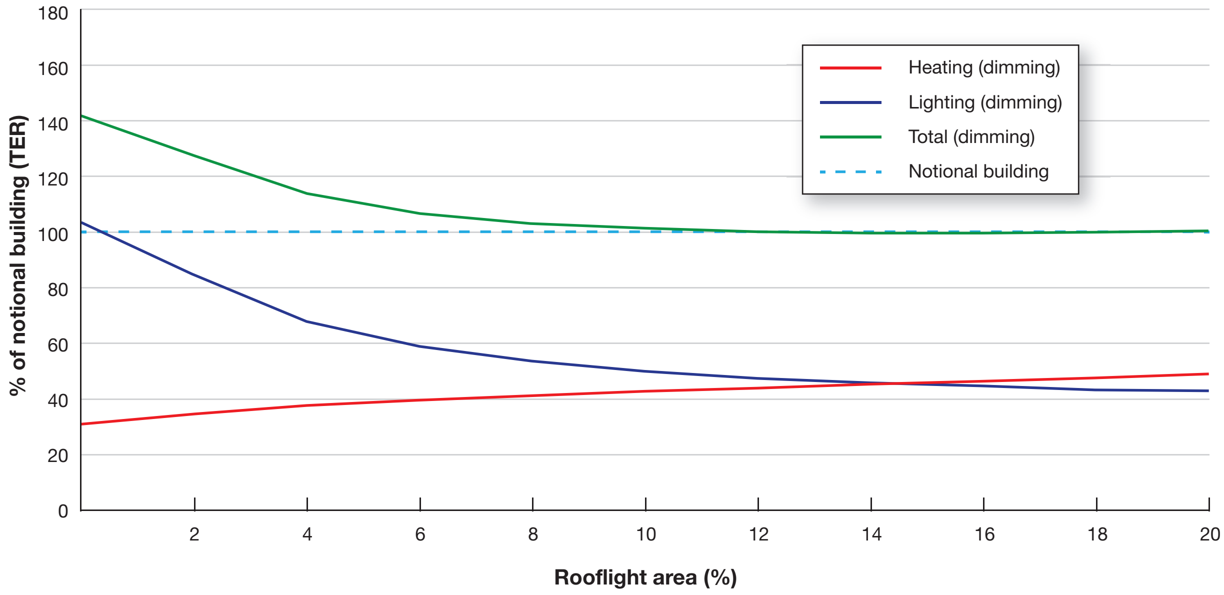
and the building will therefore remain compliant.

Table 5 Extract from ADL2A Table 5 Summary of concurrent notional building specification

Element	Side lit or unlit (where HVAC specification is heating only)	Side lit or unlit (where HVAC specification includes cooling)	Top lit
Roof U-value (W/m²K)	0.18	0.18	0.18
Wall U-value (W/m²K)	0.26	0.26	0.26
Floor U-value (W/m²K)	0.22	0.22	0.22
Window U-value (W/m²K)	1.6 (10%FF)	1.6 (10%FF)	N/A
G-value(%)	40	40	N/A
Light transmission (%)	71	71	N/A
Roof-light U-value (W/m²K)	N/A	N/A	1.8 (15%FF)
G-value (%)	N/A	N/A	55
Light transmission (%)	N/A	N/A	60
Lighting luminaire (lm/circuit watt)	60	60	60
Occupancy control (Yes/No)	Yes	Yes	Yes
Day-light control (Yes/No)	Yes	Yes	Yes

SBEM Results
If an actual building is modelled within SBEM with all parameters defined exactly in accordance with the Notional Building (including 12% rooflights with 60% light transmission and proportional control of the electric lighting system), then the SBEM results show the same CO_2. If all other parameters are then left unchanged, but rooflight area is altered, the following graph (showing results calculated by SBEM v5.2.b) demonstrates the effect on CO_2 emissions:

Graph 1: SBEM results - CO_2 emissions for the Notional Building at varying rooflight area



It can be seen from this graph that:

- at 12% rooflight area the actual building has exactly the same CO_2 emissions as the notional building i.e. the BER exactly matches the TER (100% of TER) so is a marginal pass

- as rooflight area is reduced there are dramatic increases in CO_2 emissions due to use of the lighting system whilst there are smaller reductions in CO_2 emissions due to use of the heating system. This gives a dramatic increase in total CO_2 emissions.

- if rooflights are omitted entirely, then

    - total CO_2 emissions from all aspects of operation of the building are 42% higher than they are with 12% rooflights

    - CO_2 emissions from the lighting system are 220% higher than they are with 12% rooflights

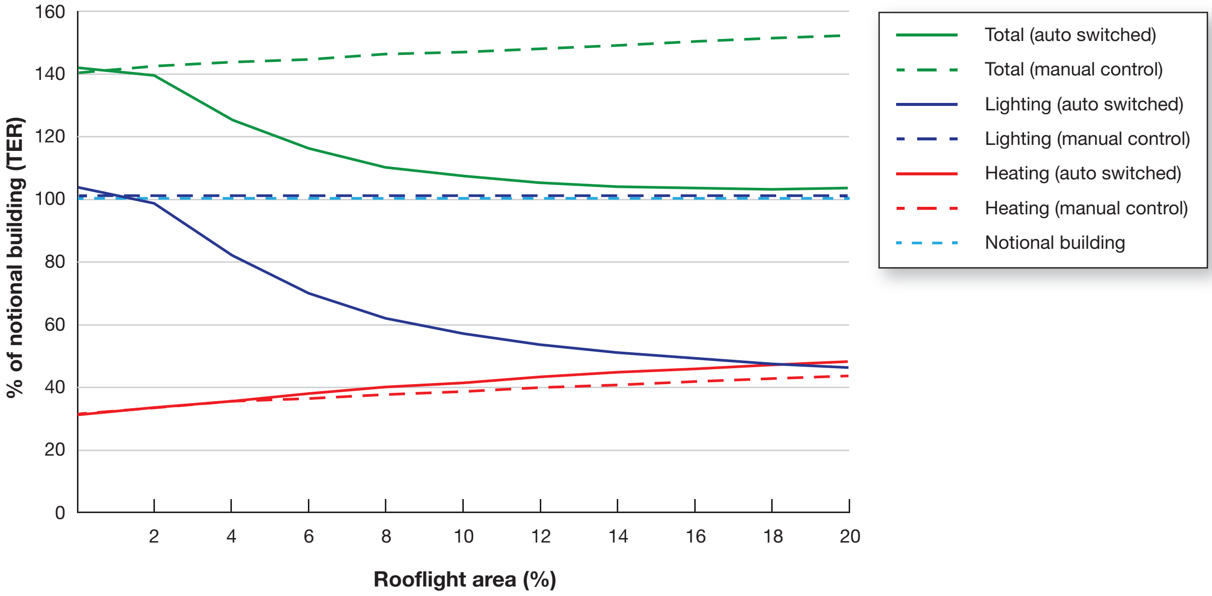
    - CO_2 emissions from the lighting system alone are higher than the total permissible CO_2 emissions from all aspects of operation

- this does not mean that rooflights cannot be omitted, but it does mean that the efficiency of the lighting system would have to be dramatically improved compared to the specification in the notional building, which already reflects current good practice

- as rooflight area is increased from 12% to 20% there is a small reduction in CO_2 emissions due to use of the lighting system, almost balanced by a small increase in CO_2 emissions due to use of the heating system, so there is little change in total CO_2 emissions

The following graph shows the same data, when less sophisticated light control systems are used – both a simple auto switched on-off system rather than the proportional (dimming) system which is defined in the notional building, and also when there is no automatic control of the lighting system.

Graph 2: SBEM results – effects of lighting control system at varying rooflight area



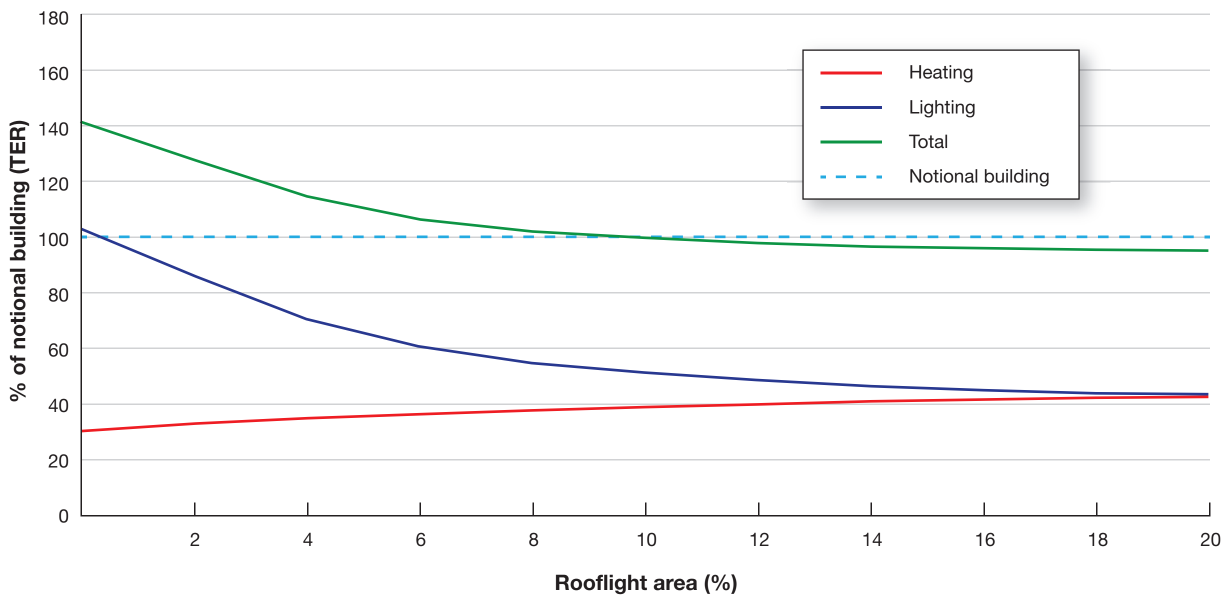
This graph shows that:

- with a simpler auto switched (on-off) system, total CO_2 emissions are slightly increased, and the building does not achieve compliance. Other improvements to the building will be required to compensate for the increased energy use of the lighting system
- without any automatic control of the lighting system SBEM assumes the lights stay on all the time (which is probably an accurate reflection of many applications), so the CO_2 emissions due to use of the lighting system are constant, at the same level as if there were no rooflights
- without automatic control, CO_2 emissions from the lighting system alone are higher than the total permissible CO_2 emissions from all aspects of operation, regardless of rooflight area. This does not mean that lighting systems must be automatically controlled, but it does mean that if they are not, the efficiency of the lighting system would have to be dramatically improved compared to the specification in the notional building, which already reflects current good practice

Graphs 1 and 2 assume that all properties of the actual rooflights are identical to those specified in the Notional Building: U-value 1.8 W/m²K, light transmission 60% and frame factor 15%. In practice, rooflight properties may be different – for example they may have slightly lower light transmission, and slightly better insulation. As an example, the following graph shows the performance of an actual building specified exactly in accordance with the Notional Building, but with:

- Light transmission 50%
- U-value 1.3W/m²K
- Frame Factor 10%

Graph 3: SBEM results – effect of varying rooflight area on CO_2 emissions for an actual building with realistic rooflight properties and dimming light controls



It can be seen from this graph that the overall trends are the same as with the notional specification rooflights: as rooflight area is reduced there are dramatic increases in CO_2 emissions due to use of the lighting system, whilst there are smaller reductions in the CO_2 emissions due to use of the heating system giving dramatic increases in total CO_2 emissions.

The graph also shows that in this case, the actual rooflights perform slightly better than the notional rooflights, so that:

- the total CO_2 emissions of the actual building with 12% rooflights are slightly better than the notional building (offering approx. 2% reduction in total CO_2 emissions)
- if rooflights are omitted entirely, then:
  - o CO_2 emissions from the lighting system are 230% higher than they are with 12% rooflights
  - o total CO_2 emissions from all aspects of operation of the building are 44% higher than they are with 12% rooflights
- as rooflight area is increased from 12% to 20%, then:
  - o the reduction in CO_2 emissions due to use of the lighting system is greater than the increase in CO_2 emissions due to use of the heating system
  - o total CO_2 emissions are reduced, giving a saving of 5% compared to the notional building

CRITERION 2 LIMITING DESIGN FLEXIBILITY (STATUTORY GUIDANCE)

In addition to limits on overall CO_2 emissions, Criterion 2 also sets limits on the worst acceptable standards for both elements of the building fabric, and services. Limits on the insulation values for the Building fabric are given in ADL2A Table 3 (note that these figures are now statutory guidance as stated in ADL2A para 1.4 Note):

AD L2A Table 3 Limiting fabric parameters	
Roof	0.25 $W/m^2.K$
Wall	0.35 $W/m^2.K$
Floor	0.25 $W/m^2.K$
Windows, roof windows, rooflights, curtain walling and pedestrian doors	2.2 $W/m^2.K$

Note that the limit of 2.2W/m^2K for rooflights is:

- the limiting U-value for windows and rooflights assumes the glazing has been assessed in the vertical position, even though rooflights are usually used horizontally. If a rooflight is assessed horizontally the limit should be increased by 0.3 W/m^2K (see AD L2A para 4.32 and BR443 section 11.1) so the limiting value is 2.5 W/m^2K when manufacturers quote rooflight performance horizontally, as they are used.
- based on the developed area of the rooflight, not the area of the roof aperture, which is defined in NARM Guidance Note NTD2 (2010)

The above table defines the worst acceptable performance for each element of the building; it should be noted that the Notional Building as detailed under Criterion 1 above are significantly higher performance, and if an actual building only complies with the worst acceptable values for building fabric and services, then it will be considerably poorer performance than the Notional Building and will fail Criterion 1.

Specifiers may therefore opt to specify rooflights with an improved U-value to match or exceed the U-values used in the Notional Building as one way of meeting Criterion 1. See ADL2A Table 5, as summarised on page 7.

Note that “plastic” rooflights will need to be at least triple skin in order to achieve the worst case U-value of 2.2W/m^2K.

To achieve higher levels of performance, rooflight manufacturers will modify the internal air gap and the internal design of the middle skin. Since this is design variable but could be critical to achieving the TER, builders and contractors need to be fully aware that changing the specification or the nominated supplier to buy cheaper options, may well fail building compliance, thus incurring far greater additional cost to reinstate the correct specification.

For buildings that produce high internal heat gains due to the process within the building, a less demanding weighted average U-value for rooflights may be an appropriate way to reduce overall CO_2 emissions and hence the BER. In such a case, the rooflight U-value may be higher than 2.2 but it should never be higher than 2.7 W/m^2K, which will still necessitate triple skin rooflights.

CRITERION 3 LIMITING THE EFFECT OF SOLAR GAIN IN SUMMER

The Regulations define measures to avoid overheating in the summer period – one of which is to limit glazed areas (windows and rooflights) to limit the solar load to limit the requirement for air conditioning.

It should be borne in mind that solar gain through windows and rooflights is just one aspect of internal gains within the building. People (including their density and activity), artificial lighting, display lighting, process equipment, computers and other equipment all contribute to internal heat gains, and along with ventilation strategy have an effect on the potential for excess heat build up.

The Regulations place limits on both window and rooflight area to limit the solar loads; they recognise the effect of solar gain is influenced by the height of the building due to the effects of stratification and the height of the rooflights above the work zone and the limits on rooflight area in AD L2A Criterion 3 para 2.53 b/c, vary depending on the building height, as follows:

Zone Height	Max Rooflight Area	Frame Factor	g value*
< 6m	10%	25%	0.68
> 6m	20%	15%	0.46

* The g value is a measure of the total transmitted solar energy: it is the direct transmission in the total solar spectrum plus the proportion of absorbed energy which is retransmitted internally.

Note that the solar load through the rooflights is defined by the product of:

Area x g-value x frame factor

and the glazing area limit will consequently be met provided this product remains the same, even if each individual parameter is different.

For example, for a taller building, if the g-value is 0.51 rather than 0.46, then the limit on rooflight area in will be reduced from 20% to 18%, because:

$$18\% \times 0.51 \times 85\% = 20\% \times 0.46 \times 85\%$$
$$(= 0.0782)$$

and similarly for a lower building, if the g-value is 0.51 rather than 0.68, then the limit on rooflight area in will be increased from 10% to 13.3%, because:

$$13.3\% \times 0.51 \times 75\% = 10\% \times 0.68 \times 75\%$$
$$(= 0.051)$$

SBEM considers the glazed areas (including both windows and rooflights) for each individual zone of the building on the above basis, taking into account the glazed area and frame factor in the zone, the height of the zone, and the glazing gvalue, and output shows whether the glazed area limits have been met (and how close to the limits each zone is).

In general, these limits are not usually exceeded for rooflight areas up to 17-20% in buildings over 6m tall, or for rooflight areas up to 10-15% in lower buildings, although care should be taken if there are also large areas of window in the same zone, as this could cause total glazed area to be exceeded.

Solar gain should only be considered for work zones where a person will be working for a substantial part of the day. It should not be considered for circulation spaces, transient occupancy such as toilets and spaces not intended to be occupied.

CRITERION 4 BUILDING PERFORMANCE CONSISTENT WITH BER

The Regulations require that most buildings that are not dwellings must be tested for air tightness on completion of the building structure, and the worst case acceptable value (under Criterion 2) is $10m^3/hr/m^2$ at 50 Pa, as shown in AD L2A Table 3.

In addition to meeting the worst case value, the measured air permeability must be entered into SBEM and the BER calculated accordingly, and must still meet the TER. The value used in the Notional building to calculate the TER is more demanding than the limiting values and will be based on building size/type as shown in ADL2A Table 5.

Table 5 Extract from ADL2A Table 5 Summary of concurrent notional building specification

Element	Side lit or unlit (where HVAC specification is heating only)	Side lit or unlit (where HVAC specification includes cooling)	Top lit
Air permeability ($m^3/(m^2.hour)$) Gross internal area less than or equal to 250 m^2	5	5	7
Air permeability ($m^3/(m^2.hour)$) Gross internal area greater than 250 m^2 and less than 3,500 m^2	3	3	7
Air permeability ($m^3/(m^2.hour)$) Gross internal area greater than 3,500 m^2 and less than 10,000 m^2	3	3	5
Air permeability ($m^3/(m^2.hour)$) Gross internal area greater than or equal to 10,000 m^2	3	3	3

Buildings of less than $500m^2$ do not have to be subject to the air pressure test, but if not, the BER calculation will use a value of $15m^3/hr/m^2$ at 50Pa. This will require compensating improvements in other elements of the fabric and services to ensure the BER is no worse than the TER.

This performance is very demanding, particularly on smaller buildings and attention to fine detail in the construction of the building will be critical.

For rooflights, attention to the detail of the fixing process is critical. In particular, the correct type, size and positioning of sealants, and correct compression of sealants by the use of the correct number, position, size and type of fasteners is vital. It must be noted that “in plane” rooflights to match the opaque sheeting of the roof have a different performance and fixing specification than the opaque sheeting and this must be observed by the fixer to ensure both water and air tightness. The consequences of failing the air pressure test will mean that remedial work will need to be carried out and likely to prove very expensive for those concerned.

SUMMARY OF THE REQUIREMENTS OF AD L2A ON ROOFLIGHTS

- Criterion 1 of Approved Document L2A of the 2013 Regulations requires an actual building to match the performance of a Notional Building which will give an overall 9% saving in energy use and associated CO_2 emissions compared to 2010 regulations.

- The major savings will need to come from the building services. Some improvement will come from improving the U-value of the building fabric but the impact of more and more insulation is a law of diminishing returns.

- Rooflights offer opportunity for dramatic savings in the overall CO_2 emissions by reducing the use of electric lighting systems, often the biggest source of CO_2 emissions when operating a building.

- Rooflights are also a very positive means of saving energy. Natural daylight is free and provides the essential feel good factor at the place of work and as a result people work more efficiently. Rooflights are an ideal way to reduce the building energy demand when designers are struggling to find that additional energy saving that will achieve compliance.

- The Notional Building has 12% rooflights. Rooflight area in the actual building is critical to matching the TER and achieving compliance: omission of rooflights can increase the total CO_2 emissions by 50% making compliance very difficult.

- Specification of as high a rooflight area as practical, with rooflights as well insulated as possible, should be considered to help meet the TER and achieve compliance.

- Automatic control of artificial lights is critical to harness the benefits offered by rooflights and achieve compliance; manual light switching in a work zone is unlikely to provide a compliant building. Proportional (dimming) control is better than switching (on/off) automatic control.

- Criterion 2 is now statutory guidance that requires that rooflights should have a U-value of 2.2W/m^{2}K or better, which means they should be at least triple skin. Use of rooflights with a U-value of 1.8 W/m^{2}K (to match the Notional Building) or significantly better U-values can be considered by the specifier as a useful way to help meet the TER, but this is not a requirement.

- Criterion 3 sets limits on glazed areas to avoid excessive solar load and care should be taken not to exceed these areas – typically 17-20% for buildings over 6metres tall, and 10-15% for lower buildings.

- Attention to detail on the fixing of rooflights to the manufacturers recommendations will be critical to achieve a compliant Air Permeability test and achieve Criterion 4.

- Designers/builders will require full technical details from the NARM manufacturer which will include - U-value, frame factor, light transmission and g value. These will vary dependant on the product, design and manufacturer. The data input into SBEM may be very critical to achieving Compliance. Contractors need to be aware that changing the designer's specification to save money on product price may lead to a Non-Compliant building and resulting extra costs to rectify the non-compliance.

- The Notional Building is the same size and shape of the actual building. A wider set of Notional Buildings has been defined and the data embedded within the Notional Building/SBEM has now been released in Table 5. Design and build in accordance with parameters in Table 5 will provide compliance to the TER.

In summary:

- o for work zones < 6m high, rooflight areas should be 10-15% of the floor area.

- o for work zones > 6m high, rooflight areas should be 12-20% of the floor area.

For a smaller carbon footprint just add rooflights

AD L2B WORK ON EXISTING BUILDINGS THAT ARE NOT DWELLINGS

Introduction
The Government have announced that the ADL2B 2010 Regulation –"Work on existing buildings that are not dwellings" will remain in force at 2013/2014. It was suggested that there would be changes to the Regulations in respect of "Consequential Improvements", but this will not happen in the foreseeable future. Thus ADL2B has not been issued for 2013, the 2010 Regulations still being in force. However there are a number of Approved Amendments to the 2010 edition that have been issued. These are generally of minor detail and will not be identified in this document except for changes to ADL2B 2010 Table 3 and to ADL2B 2010 Annex A –Document References which are identified in the text below.

For convenience all the NARM references to ADL2B 2010 in the "Designing for Rooflights 2010" document, will be reissued in this 2013/14 edition and will also include for the amendments as indicated above.

This NARM guidance document is designed to assist the reader to understand the Guidance in ADL2B in respect of the use and application of rooflights.

There are four areas of work to consider :-

- Repairs
- Refurbishments
- New Extensions
- Consequential Improvements

Buildings exempt from AD L2B

- Section 1 Listed Buildings and some buildings in Conservation Areas
- Buildings primarily used for worship
- Stand alone buildings of less than 50m^2 useful floor area
- Certain porches and conservatories of less than 30m^2 where the heating system is not extended into the porch or conservatory
- Certain historic buildings where there is a requirement to match the original building
- Buildings with low energy demand

Large Buildings
Where the extension is greater than 100m2 and greater than 25% of the useful floor area of the existing building, then the work is regarded as a New Building and must comply to the requirements of AD L2A. In addition, the requirement for consequential improvements to the original building will also apply, as explained below.

Definitions within ADL2B 2010
The following terms are used within AD L2B Regulations and are referred to in this document.

- **Thermal Element**
  This is defined as the fabric of the building to include floor, walls and roof but does not include windows, rooflights and doors.
- **Controlled Fittings**
  Rooflights, along with windows and doors, are not considered as part of the "fabric" of the building but are regarded as Controlled Fittings and considered separately from the building fabric
- **Fixed Building Services**
  This includes fixed internal artificial lighting systems and fixed systems for heating, air conditioning and medical ventilation

1. REPAIRS TO ROOFLIGHTS

Windows, rooflights and doors are defined as Controlled Fittings; this definition includes any frames. If the glazing of a rooflight is being replaced without replacing the frame, then a new Controlled Fitting is not being fitted and AD L2B does not apply (see AD L2B para 4.23).

Consequently, if replacing the glazing of an individual rooflight without replacing the frame (e.g. the upstand or the surrounding opaque sheeting), replacing like with like will be acceptable even if the original rooflight is single skin – although where practical, it would be sensible to upgrade to Part L standards.

Where the glazing of all rooflights on a building is being replaced, even if the frames are not, it is likely to be regarded as refurbishment rather than repair and the requirements of AD L2B will apply; see below.

Where a whole rooflight including the frame ie a Controlled Fitting, is being replaced, then the requirements of AD L2B as detailed below apply.

2. REFURBISHMENT TO ROOFLIGHTS

ADL2B 2010 Table 3 has been amended in the 2013 Amendments. The revised Table 3 is given below as it relates to rooflights/roof windows.

AD L2B Table 3 Standards for Controlled Fittings	
Fitting	**Standard**
Windows in buildings that are essentially domestic in character[2]	A window Energy Rating[3] of Band C or U-value 1.6 $W/m^2.K$
All other windows and roofwindows and rooflights[1,4]	U-value 1.8 W/m^2K for the whole unit

Notes to Table 3

1 Display windows are not required to meet the standard in this Table

2 For example Student Accomodation where occupancy levels are essentially domestic in character.

3 See Guide to Energy Rating for Roof Windows GGF 2013 at www.ggf.org.uk

4 For the purpose of checking compliance with this Table 3, the true U-value based on aperture area can be converted to the U-value based on the developed area of the rooflight – see NARM technical Document NTD2 (2010)

Comments to Table 3

- These limits on U-values assume the window or rooflight has been assessed in the vertical position, even though rooflights are usually used horizontally. If a rooflight is assessed horizontally, these limits should be increased by 0.3 W/m^2K (see AD L2B para 4.26), so 2.1W/m^2K is the limiting value when manufacturers quote rooflight performance horizontally, as they are used.
- For plastic rooflights this will always require a triple skin rooflight.
- Plastic rooflights are normally supplied, in the UK, in Glass Reinforced Polyester (GRP) or Polycarbonate. Other materials are available from abroad but such materials will generally fail the UK requirements for non-fragility and/or the fire resistance Regulations.

In buildings with high internal heat gains from a manufacturing process, a less demanding U-value for rooflights may be appropriate. In such cases the requirements to AD L2B Table 3 may be relaxed but the value should not be worse than 2.7 W/m^2K, which will still require a triple skin rooflight.

3. NEW EXTENSIONS

Work on extensions which are less than 100m^2, or are less than 25% of the existing floor area, fall under AD L2B and as a general rule will be measured by the Elemental Method i.e products achieving a minimum specified performance.

However, the use of SBEM to calculate the buildings performance and compare CO_2 emissions from the actual building to a Notional Building (as Criterion 1 under AD L2A) can be used as an alternative means to show Compliance (see AD L2B paras 4.9-4.11).

When designing an Extension, Controlled Fittings (including rooflights) should meet the standards shown in Table 3 (see above) - U-values should be 1.8 W/m^{2}K (when measured in the vertical plane, or 2.1W/m^{2}K when measured in the horizontal plane).

The areas of windows and rooflights should not exceed the values shown in Table 2.

AD L2B Table 2 Opening Areas in the Extension

Building type	Windows and personnel doors as % of exposed wall	Rooflights as % 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
Vehicle access doors and display windows and similar glazing	As required	N/A

Comments to Table 2
If the original building had a rooflight area greater than 20% of the roof area, rooflight area in the extension can match the area in the original building, rather than the areas in Table 2 (see AD L2B para 4.4)

It is also permitted to vary the U-values shown in Table 3 and the opening areas shown in Table 2 provided that the area weighted U-value of all the elements of the extension is no greater than that of an extension of the same size and shape that complies with Tables 2 and 3 (see AD L2B para 4.7-4.8).

The norm for a new extension will be to fit rooflights up to 20% of the roof area with a U-value of 1.8 W/m^{2}K (measured in the vertical plane).

Note that since it will be unlikely that a SBEM calculation will be carried out which will verify the point, designers need to recognise that, where appropriate, it is essential to incorporate rooflights into the design to reduce the carbon footprint of the building.

Conservatory Extensions
Where the extension is a Conservatory or a Porch and is not exempt, then reasonable provision will be :-

- Effective thermal separation between the existing building and the extension
- Independent temperature and on/off controls within the extension
- Glazed area should meet the Standards to Table 3 above. However the limitation to total glazed area in Table 2 will not apply

4. CONSEQUENTIAL IMPROVEMENTS

Where an existing building has a floor area over 1000m^2, and work is to be carried out on the building by way of an extension, or the initial provision or a capacity increase of any fixed building services, then a requirement **for consequential improvement** to the building is triggered.

These are to improve the energy performance of the original building, in addition to the proposed building work (the "principal works"), and should be to a value of at least 10% of the principal works. The principal works must still comply with Part L in the normal way.

Consequential improvement is only required if both technically and economically feasible, the latter defined by a simple payback of 15 years (see AD L2B Key Terms 3.1)

AD L2B provides a list of 9 possible measures to upgrade the original building in Table 6 "Improvements that in ordinary circumstances are practical and economically feasible"

Item 7 in AD L2B Table 6 identifies "Replacing existing windows, roof windows or rooflights or doors which have a U-value worse than 3.3 W/m^{2}K" as one such measure, and this example is used in the text (see AD L2B para 6.4).

If, as well as extending a building, old rooflights that have U-values greater than 3.3 are replaced with new rooflights that have U-value of 1.8

W/m^{2}K (when measured in the vertical plane) this would satisfy the requirement for consequential improvements, provided the cost of the rooflight replacement was at least 10% of the cost of the extension.

Since there will be a basic requirement for this level of financial commitment to upgrade the original building there will be considerable advantage to selecting this option as the method of providing consequential improvement, since:

- There will be considerable thermal efficiency savings by replacing old rooflights at a U-value in excess of 3.3 W/m^{2}K with new rooflights at a U-value of 1.8W/m^{2}K
- The old rooflights may have lost a large part of their light transmitting qualities – new rooflights will put daylight back into the building to make it a more pleasant place to work
- The additional daylight will mean the electric lights can be switched off creating further considerable energy savings and reduction in CO_2 emissions
- The new rooflights will be non-fragile making the roof a safer place should maintenance staff need to access the roof (but note that the opaque roof areas may also be fragile and remain so after the rooflights have been replaced)

SUMMARY TO AD L2B

1. The requirement for any rooflight which is refurbished or replaced, and for new rooflights in extensions, is a U-value of 1.8W/m^{2}K when measured in the vertical plane. This means that rooflights will be triple skin as shown in AD L2B 2010 Table 3 as amended in 2013.

2. The norm for rooflight area in extensions will be up to 20% of the roof area as shown in AD L2B Table 2.

3. It would be sensible for the designer to consider rooflight area carefully, to maximise the benefits of daylight on both energy use and the internal environment whilst avoiding solar overheating as outlined under AD L2A, although these considerations are not requirements of AD L2B.

4. Repairs to individual rooflights, where theglazing is replaced within the existing frame, do not fall under the requirements of Part L. Thus the repair can be like for like.

5. Where Consequential Improvements are required for the original building, replacing all the original single skin rooflights with new triple skin rooflights will be a very carbon and cost efficient solution with the added bonus that the people inside the building will greatly appreciate the better working conditions.

FREQUENTLY ASKED QUESTIONS ON ROOFLIGHT REFURBISHMENT

1. **What am I required to do if replacing or repairing an individual broken rooflight?**

   Replacement of the glazing without replacing the frame of a rooflight is not regarded as replacement of the Controlled Fitting so does not come under the scope of Part L, and like for like replacement is permissible (see AD L2B para 4.23).

   This is also likely to be the situation if replacing a damaged outer sheet on an individual in-plane rooflight.

   Replacement of a whole rooflight including the frame is defined as replacement of a Controlled Fitting and the replacement rooflight would need to achieve an overall Uvalue of 1.8 W/m^{2}K in compliance with ADL2B Table 3, so the replacement rooflight would have to be triple skin.

2. **What am I required to do if replacing degraded outer sheets of all the existing in-plane rooflights in a roof?**

   This is likely to be regarded as refurbishment rather than repair, and the upgraded rooflights would then need to achieve an overall U-value of 1.8 W/m^{2}K in compliance with ADL2B Table 3, so the replacement rooflights would have to be triple skin.

3. **What should I do if I want to add additional rooflights to the existing building?**

   For an existing building the maximum area of rooflighting is 20% of the floor area as shown in AD L2B Table 2, and new rooflights may be added up to this maximum. Any new rooflights would need to achieve an overall U-value of 1.8 W/m^{2}K in compliance with ADL2B Table 3, so the new rooflights would have to be triple skin. There is no requirement for the insulation level of the existing lights to be improved, unless they were replaced with new rooflights.

4. **I am extending the building. What control is there on any rooflights?**

   The extension may have up to 20% rooflights with a U-value of 1.8 W/m^{2}K in compliance with ADL2B Table 3, so the rooflights in the extension would have to be triple skin. If the original building had rooflights to a greater area than 20%, then the extension may be designed to the same level of rooflights as the original building. Options with more design flexibility are shown in AD L2B paras 4.7-4.8.

   Note that an extension may trigger a need for a "Consequential Improvement" on the original building, as detailed in the previous section of this document. If this is the case, upgrading the existing rooflights can be a very carbon and cost efficient solution with the added bonus that the people inside the building will greatly appreciate the better working conditions.

SUPPORTING THE GUIDANCE IN ADL1A AND ADL1B (2013)

ADL1A NEW DWELLINGS

General Comment
ADL1A gives guidance for compliance with the Building Regulations for building work carried out in England on new Dwellings.

5 CRITERIA

ADL1A defines 5 Criteria to achieve compliance for new dwellings (in the same way as AD L2A does for non-domestic buildings):

Criterion 1 : Achieving the TER and TFEE

Criterion 2 : Limits on Design Flexibility

Criterion 3 : Limiting the effect of heat gains in the summer

Criterion 4 : Dwelling actual performance is consistent with the DER and DFEE

Criterion 5 : Provision for energy efficient operation of the dwelling (this is not covered in this document)

Note that:

- Criterion 1 is a regulation and therefore mandatory
- Criterion 2 is Statutory Guidance
- Criteria 3, 4 and 5 are for guidance

CRITERION 1 ACHIEVING THE TER AND THE TFEE

Criterion 1 sets a maximum carbon dioxide emission target (in the same way as TER is set for non-domestic buildings), but in addition also sets a separate requirement for fabric energy efficiency for dwellings. The target and actual values of both the CO_2 Emission and fabric efficiency are all calculated by approved software implementing the Standard Assessment Procedure 2012 (SAP)

Target CO_2 Emission Rate (TER)
The TER is the maximum CO_2 emission rate that is allowable for any new dwelling. It is expressed in terms of the mass of CO_2 emitted per year per sq. metre of the total useful floor area of the building (kg/m^2/year).

The TER is calculated for a Notional Dwelling of the same size, shape, location and orientation as the actual dwelling, but with performance of fabric, services and controls all as defined in Appendix R of the Standard Assessment Procedure 2012, (using the formulae in AD L1A para 2.4 and the fuel factors shown in para 2.5 and Table 1). The Standard Assessment Procedure (SAP 2012) document can be downloaded from the BRE website at www.bre.co.uk/sap2012

Target Fabric Efficiency rate (TFEE)
The TFEE is the maximum energy consumption that is allowable for any new dwelling. It is expressed in terms of the energy consumed per year per sq. metre of the total useful floor area of the building (kWh/m^2/year).

The TFEE is also calculated for a Notional Dwelling of the same size, shape, location and orientation as the actual dwelling, but with performance of fabric, services and controls all as defined in Appendix R of the Standard Assessment Procedure 2012, (using the formula in AD L1A para 2.6)

Dwelling Emission Rate (DER)
The DER is the CO_2 emission rate for the actual dwelling, calculated in exactly the same way as the TER but using the actual properties of the materials and services used to construct the dwelling instead of the reference values.

Dwelling Fabric Energy Efficiency (DFEE) Rate
The DFEE is the energy consumption of the actual dwelling, calculated by SAP in exactly the same way as the TFEE but using the actual properties of the materials and services used to construct the dwelling instead of the reference values.

Compliance
All the data for the actual dwelling (geometry and full details of the building fabric and services) is entered into approved software implementing SAP, which will calculate both the target values (TER and TFEE) and the values for the actual building (DER and DFEE)

If both the DER ≤TER, and the DFEE ≤TFEE then the dwelling is compliant.

Designers and builders are free to use flexibility in the design and build provided the finished building achieves both these target values.

Notional Dwelling Specification
The reference specification for the notional dwelling is given in the SAP 2012 document Appendix R and is summarised in AD L1A section 5 Table 4. For rooflights the specification includes:

- Rooflight U-value =1.4 W/m^{2}K (assessed vertically, with an adjustment of +0.3 W/m^{2}K when installed horizontally, giving a resultant U-value of 1.7 W/m^{2}K)
- G-value = 0.63
- Light transmission = 80%
- Frame factor = 0.7
- Overshading factor = 1.0

CRITERION 2 LIMITS ON DESIGN FLEXIBILTY

In addition to limits on overall CO_2 emissions, and overall fabric efficiency set under Criterion 1, Criterion 2 sets limits on the worst acceptable standards for both elements of the building fabric, and services. Limits on the insulation values for the Building fabric are given in ADL1A Table 2 (note that these figures are now statutory guidance as stated in ADL1A para 1.4 Note):

Table 2 Limiting fabric parameters

Roof	0.20 (W/m²K)
Wall	0.30 (W/m²K)
Floor	0.25 (W/m²K)
Party wall	0.20 (W/m²K)
Swimming pool basin	0.25 (W/m²K)
Windows, roof windows, glazed roof-lights, curtain walling and pedestrian doors	2.00 (W/m²K)
Air permeability	10.0m³(h-m²) at 50 Pa

Note that the limit of 2.00 W/m²K for rooflights is:

- the area weighted average for all elements of that type. For example, if one opening and two fixed rooflights were fitted to a dwelling, the opening one could be permitted to have a worse U-value than in the above table, provided that the two fixed ones have a better U-value so that the average U-value (based on area) is as good or better than the limiting figure in Table 2
- based on rooflight U-value having been assessed in the vertical position, even though rooflights are used horizontally or on a pitched roof. If a rooflight has been assessed horizontally and installed at a pitch of less than 20 degrees then the limits should be increased by 0.5 W/m²K for double glazed units (or 0.3 W/m²K for triple glazed units), so the limiting value becomes 2.5 or 2.3 W/m²K for double, or triple, glazed rooflights respectively (see BR443 section 11.1 for adjustments at pitches above 20 degrees)
- based on the developed area of the rooflight, as defined in NARM Guidance Note NTD02, rather than the area of the aperture

The above table defines the worst acceptable performance of each element of the building; it should be noted that in common with most elements, rooflights in the Notional Dwelling (as detailed under Criterion 1) have a much higher performance, and that if the fabric and/or services are all specified to the minimum standards defined by Criterion 2, the dwelling will not achieve the overall level of performance required by Criterion 1

Specifiers may therefore opt to specify rooflights with an improved U-value to match or exceed the U-values used in the Notional Dwelling.

Note that rooflights fitted with double glazed glass with a hard coat low emissivity coating and argon filled cavity will have a centre pane U-value of 1.4 W/m²K which is likely to meet the minimum fabric parameters defined in Criterion 2. However, rooflights will need to be fitted with double glazed glass with a soft coat low emissivity coating and argon filled cavity to give a centre pane U-value of 1.1 W/m²K, to match the performance of the rooflights defined in the Notional Dwelling to meet Criterion 1. In both cases performance of the rooflight frame is critical, as the values defined in both Criteria 1 and 2 should apply to the whole rooflight value rather than centre pane U-value.

To achieve higher levels of performance triple glazing should be considered. Triple glazing options are readily available and can help make a major contribution to achieving the TER.

CRITERION 3 LIMITING THE EFFECTS OF HEAT GAINS IN SUMMER

The regulations define measures to avoid overheating in summer – one of which is to limit glazed areas (windows and rooflights) to limit the solar load, to limit the requirement for air conditioning.

It should be borne in mind that solar gain through glazing is just one aspect of internal gains within the building. People, artificial lighting and electrical appliances all contribute to internal gains.

Solar gains can be beneficial in the winter to offset demand for heating but can contribute to overheating in the summer. Specialist solar control glasses can be used to control solar gain but these will also reduce daylight levels and reduce winter solar gains. SAP 2012 assumes glass with a light transmission of 80% and a g-value of 0.63. Common soft coat low emissivity glasses will typically have a light transmission of 78% with a g-value of 0.61 for double glazing with two panes of 6mm glass. Some high performance glasses can provide a g-value of 0.41 but the corresponding light transmission drops to 68%.

To maintain good light levels the Building Regulations recommend that glazing is provided equating to a minimum of 20% of the floor area to avoid parts of the dwelling experiencing poor levels of daylight, resulting in increased use of electric lighting, and hence increasing CO_2 emissions (see Note to AD L1A para 2.41).

Effective ventilation can contribute to controlling heat gains in dwellings; opening rooflights can be an effective method of providing natural ventilation. If electrically operated they can be automatically controlled to provide daytime ventilation when required, and/or night time purging.

CRITERION 4 BUILDING PERFORMANCE CONSISTENT WITH DER AND DFEE RATE

The regulations require that dwellings should be constructed and equipped so that actual performance is consistent with the calculated DER and DFEE rate.

When calculating the DER and DFEE rates care should be taken to ensure that the correct data is entered into the software. For a rooflight,the U-value entered should be the true U-value for the whole rooflight, correctly adjusted for the actual installation angle and based on the area of the aperture in the roof (the developed area U-value, U_d, is only used to check for compliance with Criterion 2).

In addition to the actual U-value, the measured air permeability must be entered into SAP to allow it to calculate the DER and DFEE rates. The dwelling (or on larger developments a representative sample of each dwelling type) must be pressure tested to obtain this data. Where only a representative sample of a dwelling type has been tested, the average of the results is used and the figure increased by +2.0$m^3/hr/m^2$ at 50 Pa. For small developments the builder can opt not to test, in which case a value of 15.0$m^3/hr/m^2$ at 50Pa must be entered into SAP, which is significantly poorer than the value in the Notional Building, so would require other compensating improvements to be made in order for the DER to match the TER.

For rooflights, particular attention should be paid to the quality of the builder's kerb (or the roof surface where the rooflight is supplied with an upstand) and correct application of any sealants between the two to ensure an airtight seal is achieved. It is vital to follow the manufacturer's instructions carefully to ensure the declared performance is achieved. For opening rooflights the design of the seal between the fixed and opening sections and continuity of the seals at corners are critical to the air leakage performance.

ADL1B EXTENSION, REPAIR & REFURBISHMENT OF EXISTING DWELLINGS

Repairs To Rooflights
Windows, rooflights and doors, including the frames, are defined as Controlled Fittings. If only the glazing of a rooflight is being replaced within the existing frame, then a new Controlled Fitting is not being installed and ADL1B does not apply.

Where a whole rooflight or roof window, including the frame, is being replaced then the requirements of ADL1B as detailed below will apply.

Rooflights in listed buildings, buildings in conservation areas or scheduled monuments where compliance with energy efficiency requirements of ADL1B would unacceptably alter the character or appearance of the dwelling are exempted from these requirements.

Replacement Rooflights
Where the whole rooflight is being replaced then the replacement rooflight must comply with the standards specified in ADL1B Table 1.

Table 1 **Standards for controlled fitting**

Fitting	**Standard**
Window, roof window or roof-light	WER Band C or better (see paragraph 4.22), or U-value 1.6 W/m^2K
Doors with >60% of internal face glazed	Door Set Energy Rating (DSER) Band E or better (see paragraph 4.22), or U-value 1.8 W/m^2K
Other doors	DSER Band E or better (see paragraph 4.22), or U-value 1.8 W/m^2K

Notes to Table 1

• The WER referred to above is the Window Energy Rating; the WER scheme does not include rooflights. Therefore rooflights must achieve a whole-unit U-value of 1.6 W/m^2K .

• This limiting value is based on rooflight U-value having been assessed in the vertical position, even though rooflights are used horizontally or on a pitched roof. If a rooflight has been assessed horizontally and installed at a pitch of less than 20 degrees then the limits should be increased by 0.5 W/m^2K for double glazed units (or 0.3 W/m^2K for triple glazed units), so the limiting value becomes 2.1 or 1.9 W/m^2K for double, or triple, glazed rooflights respectively (see BR443 section 11.1 for adjustments at pitches above 20 degrees)

• The relevant rooflight U-value for checking against these limits is based on the developed area of the rooflight, not the area of the roof aperture. See NARM guidance note NTD2 for further detail.

• If a rooflight is enlarged or a new rooflight is fitted then the total area of windows, roof windows, rooflights and doors should not exceed 25% of the total floor area of the dwelling unless compensating measures are taken elsewhere in the work.

Note that a Building Control Body should normally be notified that the work is to take place at least 5 days before work starts. The competent person schemes (such as FENSA) which avoid the need for this are limited to doors and windows and does not include rooflights.

New Extensions

For new extensions on existing dwellings reasonable provision of glazing area would be demonstrated by limiting the total area of windows, doors, roof windows and rooflights in the extension so that it does not exceed 25% of the floor area of the extension plus the total area of all doors and windows which as a result of the extension works, no longer exist or are no longer exposed.

Alternatively more flexible approaches are also permitted based either on an area weighted U-value method or a whole dwelling calculation method. The area weighted method is based on demonstrating that the area weighted U-value for all the elements in the extension is no greater than that of an extension of the same size and shape that complies with the fabric standards referred to above.

The calculation method is based on using SAP 2012 and demonstrating that the CO_2 emissions for the whole building with the new extension will be no greater than the dwelling plus a notional extension built to the fabric standards above.

In order to achieve this it may be necessary to upgrade elements to the existing dwelling; a good way to contribute to this may be to replace any old rooflights or roof windows in the existing dwelling with new units that meet the minimum fabric standards set out in ADL1B.

Consequential Improvements

When an existing dwelling has a total useful floor area in excess of 1,000m^2 and work is to be carried out on either an extension, provision of new services or an increase in the capacity of existing services then consequential improvements may be triggered, if they are technically, functionally and economically feasible.

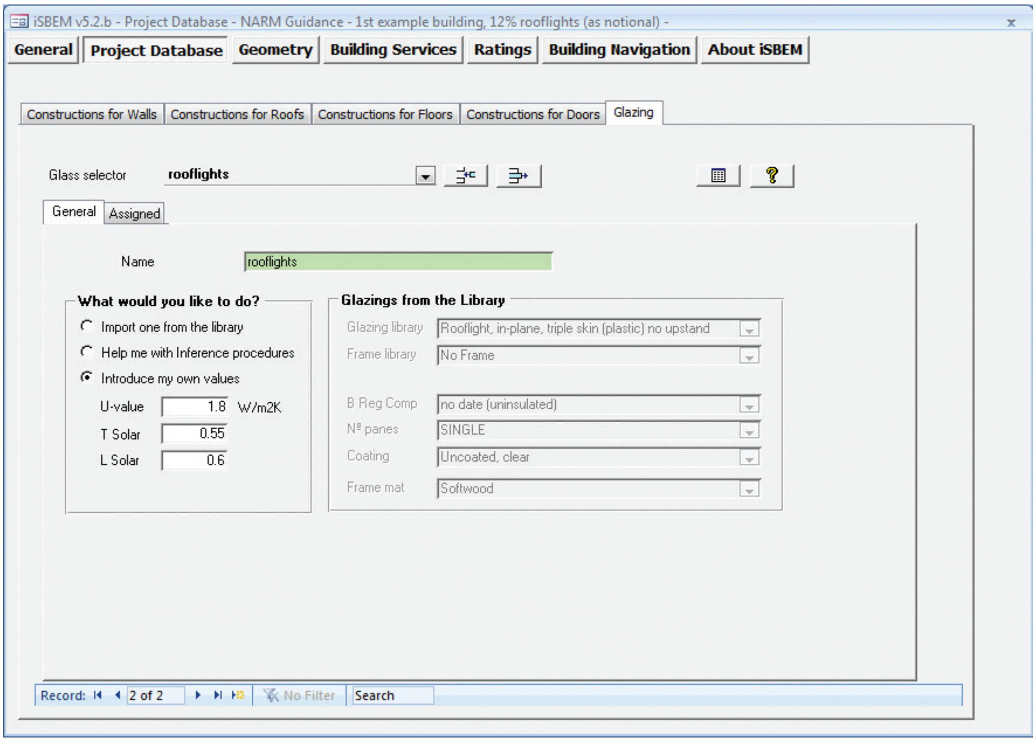
Technical guidance of consequential improvements is not provided in ADL1B but is available in ADL2B, as outlined on page 19 of this document. Replacing existing windows, roof windows, rooflights or doors which have a U-value worse than 3.3W/m^{2}K is one likely measure.

APPENDIX 1 HOW TO ENTER ROOFLIGHT DATA INTO ISBEM

All users of SBEM should be familiar with the SBEM User Manual and help facilities; this document does not attempt to explain how to use SBEM, but is intended to highlight how data specific to rooflights should be entered into SBEM, and key points to be aware of.

(a) rooflight data

For each type of rooflight which are going to be used on any particular building, the main thermal, light and solar transmission properties should be entered into SBEM in the “Project database” form, under the “Glazing” tab. It is recommended that the user uses the “Introduce my own values” option, and enters data available from rooflight manufacturers, as shown below:



Properties which should be entered for the actual rooflights are:

- U-value (in W/m^{2}K) as measured in the vertical plane
- T-solar
- L-solar

U-value
This value should include allowance for any heat loss through glazing bars and frame, not just a centre pane value and should be based on the developed area i.e. the Ud-value as defined in NARM Technical Guidance NTD2.

This value should be less than the limiting values in AD L2A and L2B - for new build it should be less than 2.2, and for refurbishment or extensions it should be less than 1.8

Note that out-of-plane rooflights are generally mounted on a kerb or upstand, which may be manufactured on site, or supplied as part of the rooflight.

Where kerbs are supplied with the rooflight, they should be regarded as part of the rooflight, and the Ud-value for both the rooflight alone, and the rooflight-and-kerb assembly should be calculated in accordance with NARM Guidance Note NTD2. Both values must achieve the relevant limiting value (2.2 or 1.8 W/m²K), and the value for the the rooflight-and-kerb assembly should be entered into SBEM.

Where kerbs are existing or manufactured on site, they can either be regarded as part of the rooflight and analysed as above, or regarded as part of the roof in which case they should meet the requirements for the roof, or where less well insulated treated as a thermal bridge.

T-solar

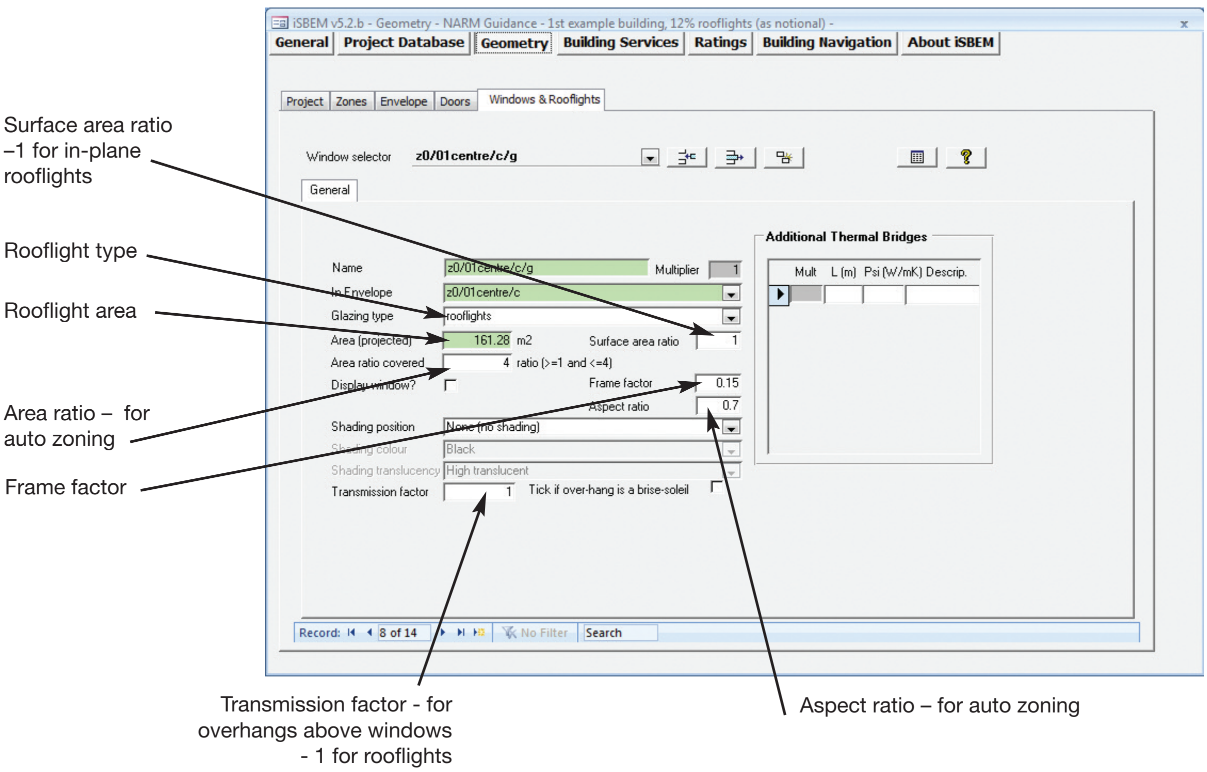
T-solar is the total solar transmittance, or the G-value of the actual rooflight. This is used only for solar overheating calculations (not for CO_2 emission calculations)

L-solar

L-solar is the light transmission of the actual rooflight. This is used only for CO_2 emission calculations to determine whether the actual building achieves the TER (not for solar overheating calculations)

(b) rooflight geometry

Once all the rooflight properties have been entered in the "Project Database" form, the geometry of each rooflight should be entered in the "Geometry" form, under the "Windows and Rooflights" tab:



Properties which should be entered for each actual rooflights are:

- In Envelope
- Glazing Type
- Area (projected)
- Shading System
- Transmission factor
- Surface Area ratio
- Frame factor
- Area ratio covered
- Aspect ratio

In Envelope
This simply defines the specific element of the building that the rooflight is positioned in

Glazing Type
This refers to the description of the relevant rooflight type as already entered into the Project database form, and ensures the correct thermal, light and solar transmission properties are used

Area (projected)
This is the projected area of the actual rooflight (not the developed area as defined in NARM NTD2 which is used for U-value calculations), and is the area used for illumination and solar gain calculations

Shading System
This relates to shading systems such as blinds which rarely applies to rooflights, so this should usually be set "All other cases"

Transmission factor
This is related to loss of transmission due to shading eg from overhangs above windows, which rarely applies to rooflights so this should usually be set to 1

Surface Area ratio
This is the ratio of the developed (ie surface) area of the rooflight (as defined in NARM Guidance Note NTD2, and used to calculate the U_d-value) to the projected area. By definition, this is also the ratio of the true U-value to the U_d-value.

If the surface area ratio for a particular rooflight is not available, an acceptable alternative is to enter the true U-value (based on projected area) into the Project Database form then enter a value of 1 as surface area ratio, as this will give the correct heat loss.

However, if the U-value entered into the Project Database form is a U_d-value based on a developed area that is greater than the projected area (giving a U_d-value which is lower than the U-value), then the surface area ratio must be entered correctly.

Note that for in-plane rooflights, because the effect of profile can affect developed area dramatically, the U-value quoted is usually the true U-value rather than a U_d-value, and a surface area ratio of 1 should therefore be used.

For out-of-plane rooflights, it is more common to quote the Ud-value (for comparison to the limiting values in AD L2A and L2B) and the corresponding surface area ratio must be entered.

Frame factor
This is the percentage of the rooflight area which is not glazed.

For in-plane rooflights, this is the proportion of the area covered by opaque sheet at laps (side and end) and purlins.

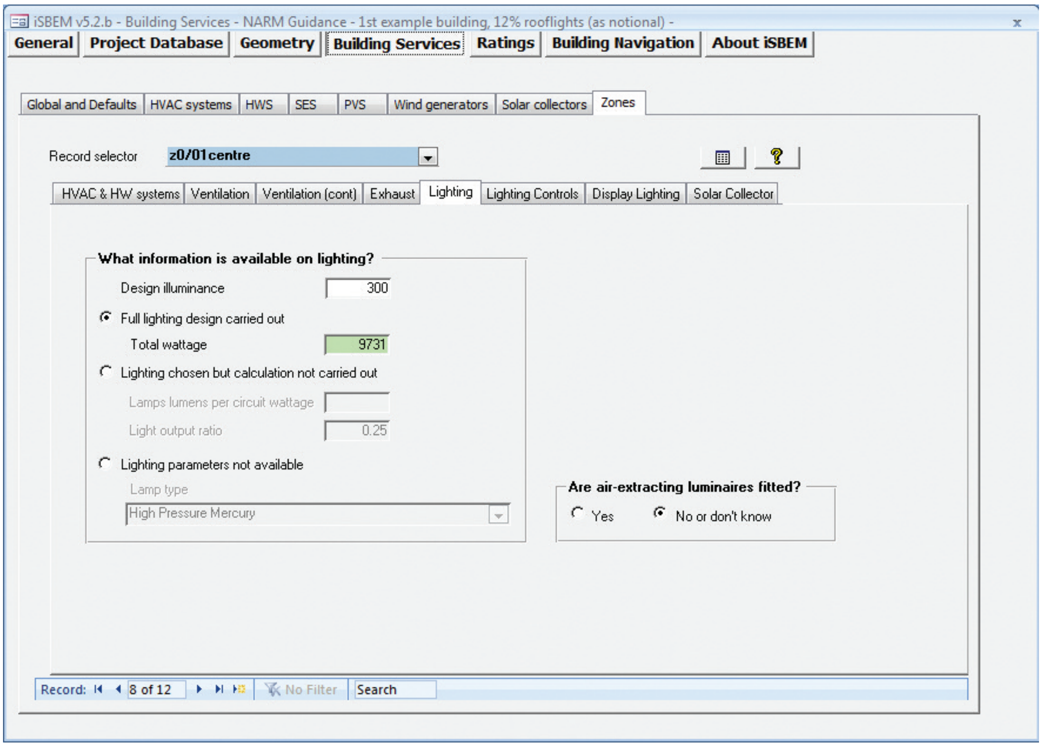
For out-of-plane rooflights, this includes any glazing bars, or effective reduction in area due to splayed kerbs.

Area ratio covered
This is a factor used when automatic daylight zoning is selected, but SBEM does not now subdivide rooflit zones, so this parameter is no longer relevant for rooflights. It referred to the ratio of the floor area illuminated by rooflights divided by the rooflight area.

Aspect ratio
This is also a factor only used when automatic daylight zoning is used, but SBEM does not now subdivide rooflit zones, so this parameter is no longer relevant for rooflights. It defined the ratio of the length: width of the rooflight which SBEM assumes.

(c) Lighting system

Details of the lighting system are entered in the “Building Services” form, under the “zones” tab, Generally, details for a full lighting design have to be entered for each zone:



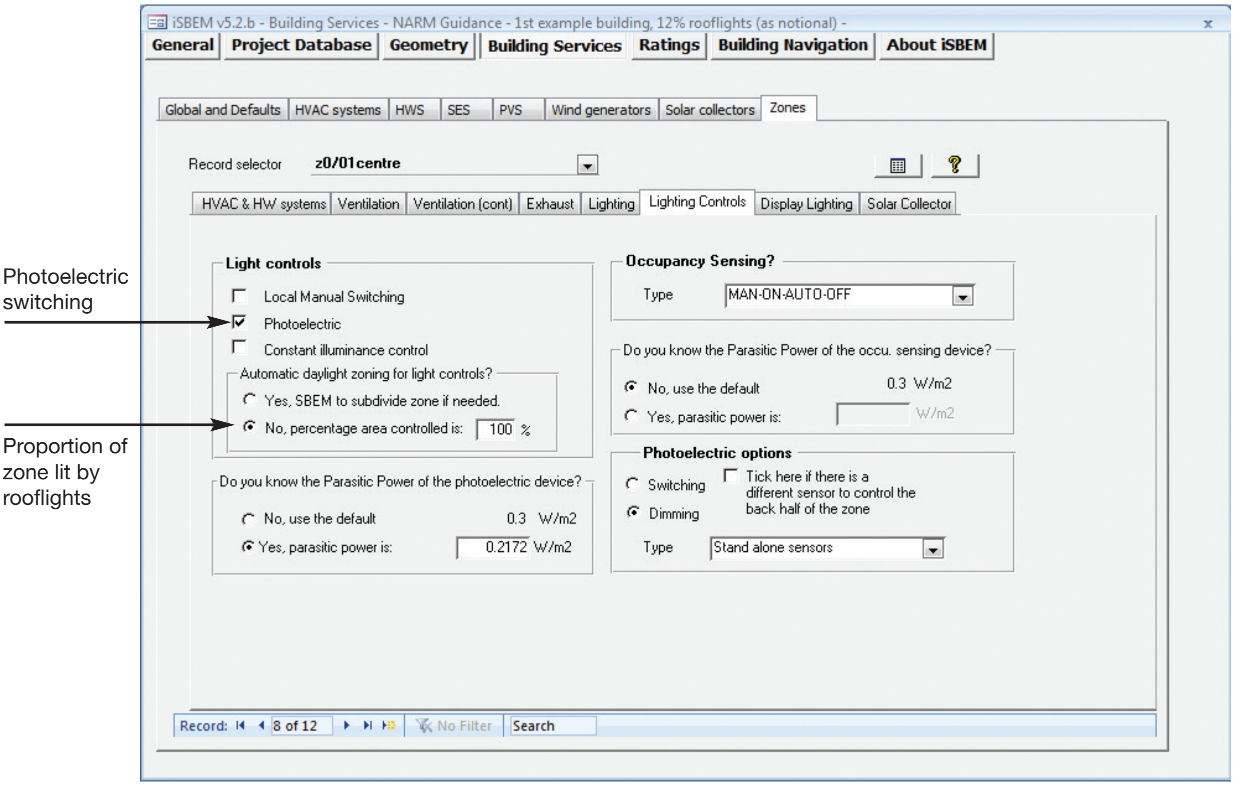
The wattage of the lights in each zone and the design illuminance they are designed to achieve have to be entered into SBEM: the latter is the illuminance which the lighting system is expected to achieve not the design illuminance for the zone, which is fixed in the SBEM database, depending on the activity in the zone. Entering a higher figure does not imply a brighter internal environment, it just means a more efficient lighting system has been defined.

Note that details of the efficiency of lighting systems assumed in the Notional Building are shown on pages 20-21 of the National Calculation methodology modelling guide 2013. It assumes lighting with an efficacy of 60 luminaire lumens per circuit-watt, and Equation 7 defines the actual power density (ie the watts per 100lux), which depends on the zone geometry.

(d) Lighting control system

It is essential that correct control of the artificial lighting system is defined (as detailed in Graph 2 of this report): without automatic control of the lighting system SBEM assumes the lights stay on all the time regardless of available daylight, so that in the example building, CO_2 emissions from the lighting system alone are higher than the total permissible CO_2 emissions from all aspects of operation, having a dramatic negative impact on overall performance of the building and making compliance extremely difficult.

Details of the lighting control system are entered in the "Building Services" form, under the "zones" tab, and the "lighting (Controls)" subtab.



Properties which should be entered for the lighting control system in every zone are:

- Light Controls
- Automatic daylight zoning for light controls
- Photoelectric options
- Occupancy sensing
- Parasitic power

Light Controls
The "photoelectric" box should always be ticked if the actual building has automatic control of the lighting system – and for many buildings this will be critical in order to achieve compliance.

Note that the Notional Building includes photoelectric contol of the lighting system for rooflit zones.

Automatic daylight zoning for light controls
SBEM does not now subdivide zones for rooflit areas, but assumes rooflights illuminate a zone evenly.

For clarity, it is recommended to select "No, percentage controlled is" and enter 100% - this is the percentage of the area of a zone that is illuminated by the rooflights. If the rooflights are not distributed evenly but only illuminate part of a zone, an appropriately lower figure should be entered here.

Photoelectric options
The "switching" (ie on-off control) or "dimming" (ie proportional) option can be selected here, depending on the type of lighting control system being specified for the actual building.

Graphs 1 and 2 of this document show the effect of this change – dimming controls give greater saving in energy consumption of the lighting sytem.

Note that the Notional Building includes dimming contol of the lighting system for rooflit zones.

Parasitic power
This is the energy used by the lighting sensors and control system even when the lights themselves are turned off, and will depend on the specification of the lighting control system to be used in the actual building

Note that the Notional Building assumes parasitic power to be the lesser of 3% of the installed lighting load, or 0.3 W/m^2.

APPENDIX 2 THE DE MONTFORT RESEARCH

Assessing the overall impact of rooflights and glazing on the energy efficiency of a building is a complex task, and detailed research has been carried out by The Institute of Energy and Sustainable Development at De Montfort University.

Consideration was given to the difference in insulation value between rooflights and the surrounding cladding, balanced against the passive solar gain through the glazing and the amount of energy needed to artificially light the building whenever there is insufficient natural light. The amount of energy required to provide artificial light is much greater than the energy needed to compensate for loss of heat through the rooflight.

Thermal and lighting analysis was undertaken using state of the art software to process actual weather data for a test reference year at a number of locations around the country, assessed on an hour-by-hour basis for a whole year. It analysed the heat flow and illuminance through an entire roof including rooflights covering between 0 and 20% of the roof area.

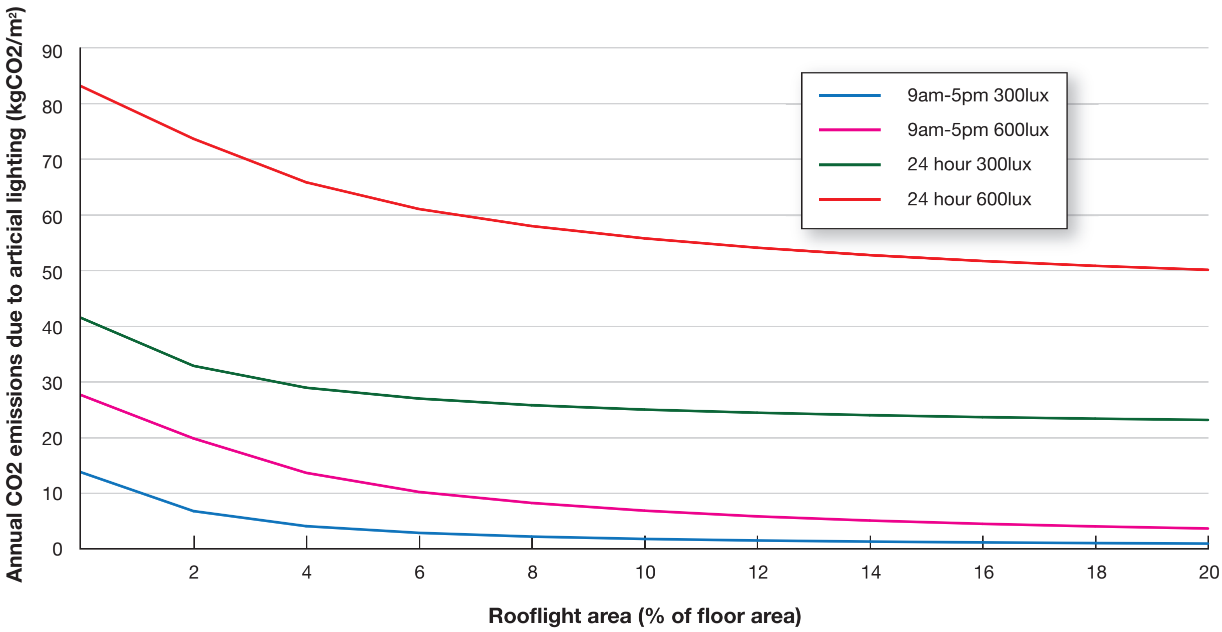
Thermal analysis used 'EnergyPlus' software, widely recognised as the most accurate available for this type of work, and significantly more accurate than the SBEM software used for Part L compliance. This took account of the different insulation values of the roof and rooflights, differing internal and external temperatures, radiant heat on the roof, and included the beneficial effect of passive solar gain through the rooflights. Results show the effect of rooflight area on heat flow through the whole roof, which is the only heating load affected by rooflight area: it did not assess heat loss through the rest of the building where there are many more variables.

Illumination levels inside a building for different rooflight areas and types were also calculated. The design illumination level, and efficiency of the lighting and lighting control systems define the energy needed to provide artificial lighting. The results show the effect of rooflight area on annual lighting system energy use and allow the effects of different patterns of building use (eg design illumination levels and hours of use) to be assessed.

Data for the energy used by heating and lighting systems was combined and converted into equivalent CO_2 emissions to show the overall effect that rooflight area has on total CO_2 emissions.

The findings prove conclusively that rooflights provide an overall energy benefit - with the level of that benefit depending on many factors, particularly the area of rooflights installed, design

Figure 1: Effect of rooflight area on CO2 emissions due to artificial lighting system



illumination level, type of artificial lighting control used and the pattern (hours) of building use.

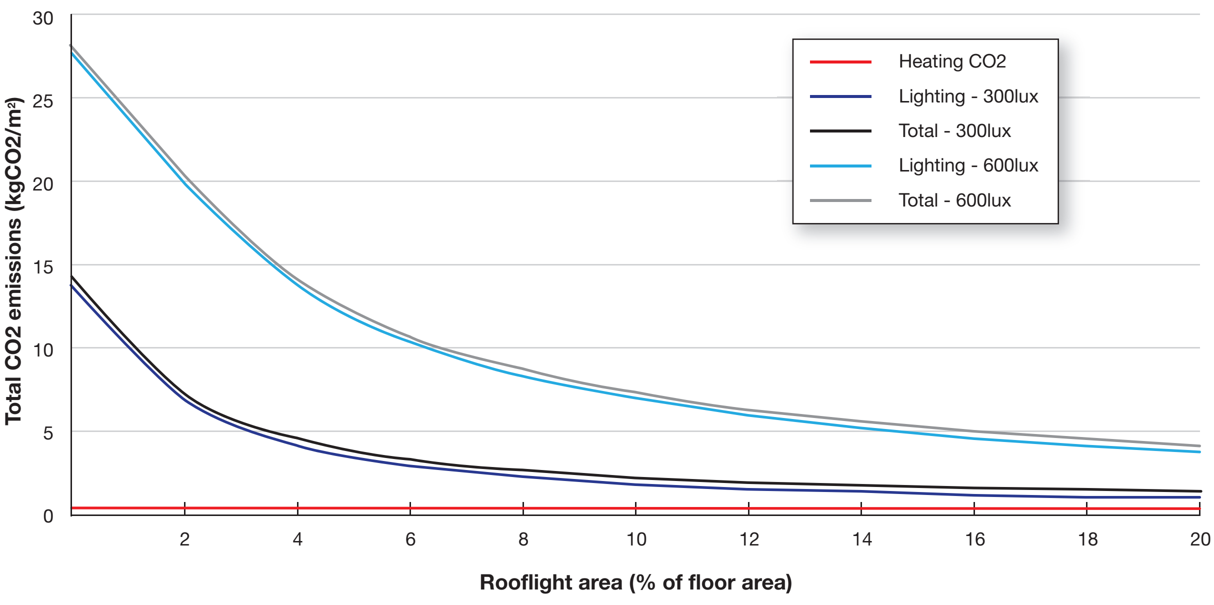
Lighting level is measured in lux. The level of lighting required within a building will depend upon the building's use. The model created by the research allows lux levels to vary. The illustrations below use 300 and 600 lux. A light level of 300 lux is moderate giving adequate lighting for general activities and circulation spaces such as packaging areas. A light level of 600 lux would be required where a degree of colour judgement was required or more detailed visual tasks were taking place such as in many retail and office environments, or product assembly areas.

Figure 1 clearly shows that the greater the rooflight area, the less artificial light is required - and hence the lower the total power consumption. The higher the illumination level, the greater the lighting system's power consumption will be - and the greater the saving which can be offered by increasing rooflight area.

Figure 2 shows the overall effect of rooflight area on CO_2 emissions for a building used 9am-5pm. The red line shows the effect on emissions due to the energy use of the heating system for heat loss through the roof (only), the blue lines show the effects on emissions due to the energy use of the lighting system for both 300 and 600 lux (as shown in Figure 1), and the black line shows the sum total of heating and lighting.

For example, with 300 lux illumination and 9am-5pm use, there is a reduction in lighting system's CO_2 emissions from 14 to 1 $kgCO_2/m^2$ as rooflight area increases from 0 to 20%. As hours of use increase, the overall energy use increases and so does the saving: a saving of 18 $kgCO_2/m^2$ per annum is made for 24 hour use. At an illumination level of 600 lux, an increase in rooflight area from 0 to 20% results in a saving of 25 $kgCO_2/m^2$ for 9am-5pm use and up to 33 $kgCO_2/m^2$ for 24 hour use.

Figure 2: Effect of rooflight area on CO2 emissions - 9am-5pm



Increasing the rooflight area reduces the need for artificial light, cuts the energy requirement of the building and reduces CO_2 emissions.

Note that an increase in rooflight area (at least within the range 0 to 20%) will result in a dramatic reduction in total CO_2 emissions. Based on traditional considerations of insulation value alone, it may have been expected that the heating energy requirement would increase as rooflight area increased, but the research proves that for a building occupied primarily during the day this is not the case. Passive solar gain through the rooflights actually balances the insulation value, so heating requirements are barely affected and by far the dominant effect is the decreasing requirement for artificial light as rooflight area is increased.

The worst case scenario for rooflights is a building that is occupied 24 hours a day because during the night there are no benefits either from natural light or passive solar gain – but even in this situation rooflights still provide a very significant energy benefit.

Figure 3: Effect of rooflight area on CO2 emissions - 24 hour

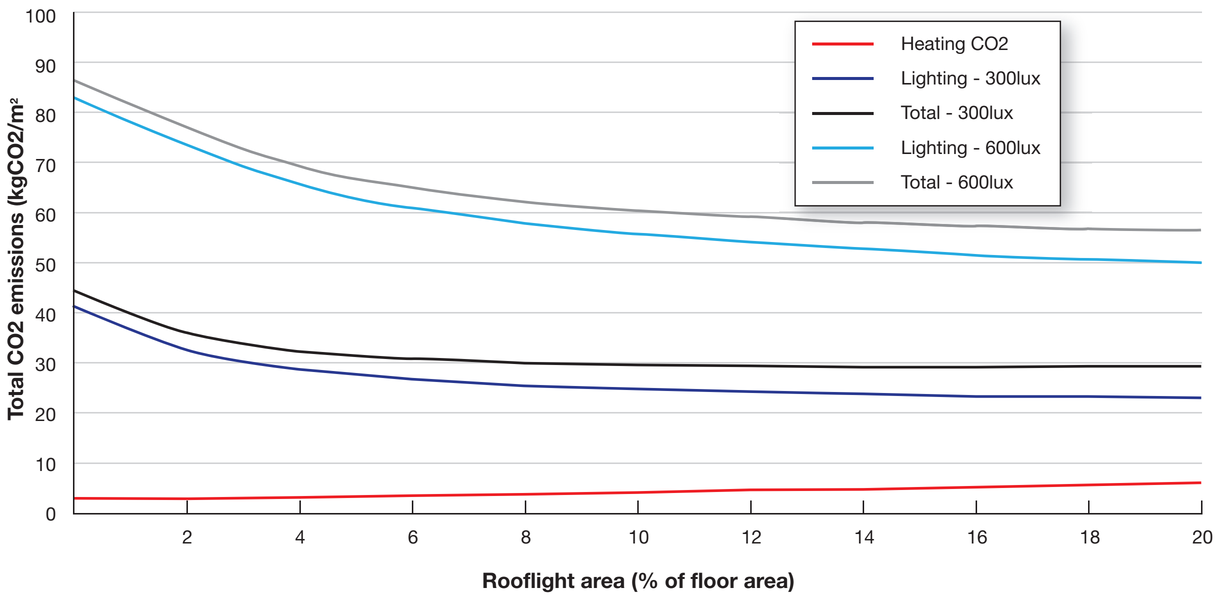


Figure 3 shows the overall effect of rooflight area on CO_2 emissions for a building used 24 hours a day. The red line again represents the heating requirement - and in this case it can be seen that the total heat loss through the whole roof approximately doubles as rooflight area increases from 0 to 20% since at night there is increased heat loss through the rooflights which is not balanced by any solar gain. However, in most cases, the savings in lighting energy requirement still far more than outweigh this.

With a lighting requirement of 600 lux the total energy use continues to drop as the rooflight area increases, up to 20%. Where the lighting requirement is a relatively low 300 lux, at rooflight areas up to approximately 14%, the savings in lighting energy are the dominant effect and total CO_2 emissions fall as rooflight area increases; at higher rooflight areas the increase in heating requirement and decrease in lighting requirement are approximately equal, so the overall CO_2 emissions then remain constant up to a rooflight area of 20%.

Conclusions of the De Montfort University Research

These examples look at 2 illumination levels (300 and 600lux) and 2 patterns of use (9am-5pm and 24 hour), clearly demonstrating that where use of rooflights is appropriate:

- rooflights always make a positive contribution: omission of rooflights gives a very significant increase in CO_2 emissions
- in most buildings, savings continue to be achieved as rooflight area is increased up to 20%
- in buildings used 24 hours a day:
    - o there are savings as rooflight area increases up to 15% in all cases
    - o where illumination levels are relatively low, the savings as rooflight area is increased from 10% to 15% are relatively minor, with very slight increases in CO_2 emissions as area increases further, to 20%
    - o at higher illumination levels, there are savings as rooflight area is increased up to 20%, but the further savings as rooflight area is increased above 15% are relatively minor

In summary, these results show that rooflight area equal to 15% - 20% of floor area may be a useful approximation of the optimum rooflight area. In some buildings there may be benefit from slightly higher rooflight areas, and occasionally the optimum may be slightly lower, so there may sometimes be small further gains available from adjustments in rooflight area - but in almost all cases a rooflight area of 15% - 20% will achieve almost all of the available savings in overall energy use and CO_2 emissions.

FULL MEMBERS

Brett Martin Daylight Systems Ltd
Sandford Close
Alderman's Green Industrial Estate
Coventry CV2 2QU
Tel: 024 7660 2022 Fax: 024 7660 2745
Web: www.brettmartin.com

Filon Products Ltd
Unit 3 Ring Road
Zone 2 Burntwood Industrial Park
Burntwood
Staffordshire WS7 3LQ
Tel: 01543 687300 Fax: 01543 687303
Web: www.filon.co.uk

Glazing Vision
Saw Mills Road
Diss, Norfolk IP22 4RG
Tel: 0333 8000 881 Fax: 0333 8000 882
Web: www.glazingvision.co.uk

Hambleside Danelaw Ltd
Long March
Daventry
Northamptonshire NN11 4NR
Tel: 01327 701900 Fax: 01327 701909
Web: www.hambleside-danelaw.co.uk

Lareine Engineering Ltd
Unit 1, Armadale Industrial Estate
Lower Bathville
Armadale, West Lothian EH48 2ND
Tel: 01501 731600 Fax: 01501 733828
Web: www.lareineengineering.com

Lonsdale Metal Company Ltd
Unit 40 Millmead Industrial Centre
Mill Mead Road, London N17 9QU
Tel: 020 8801 4221 Fax: 020 8801 1287
Web: www.roofglazing.co.uk

Surespan Ltd
Leamore Close
Leamore Enterprise Park
Walsall, West Midlands, WS2 7NL
Tel: +44 (0) 1922 711185 Fax: +44 (0) 1922 714099
Web: www.surespancovers.com

Twinfix
201 Cavendish Place
Birchwood Park, Birchwood
Warrington WA3 6WU
Tel: 01925 811311 Fax: 01925 852955
Web: www.twinfix.co.uk

Velux Company Ltd
Woodside Way
Glenrothes
Fife KY7 4ND
Tel: 01592 778225
Web: www.velux.co.uk

Xtralite (Rooflights) Ltd
Spencer Road
Blyth Riverside Business Park
Blyth, Northumberland NE24 5TG
Tel: 01670 354157 Fax: 01670 364875
Web: www.xtralite.co.uk

ASSOCIATE MEMBERS

Jet Cox Ltd
CRH House
Units 1-3
Prothero Industrial Estate
Bilport Lane
Wednesbury, West Midlands WS10 0NT
Tel: 0121 530 4230 Fax: 0121 530 4231
Web: www.coxbp.com

Keylite Roof Windows (NI)
Derry Loran Industrial Estate
Sandholes Road
Cookstown, Co. Tyrone BT80 9LU
Tel: 028 86 758921 Fax: 028 86 758923
Web: www.keyliteroofwindows.com

Kingspan Ltd
Greenfield Business Park 2
Holywell, Flintshire
North Wales CH8 7GJ
Tel: 0800 587 0090 Fax: (0) 1352 716111
Web: www.kingspanpanels.com

Roofglaze Ltd
Unit 4 Little End Road
Eaton Socon
St Neots
Cambridgeshire PE19 8JH
Tel: 01480 474797 Fax: 01480 474774
Web: www.roofglaze.co.uk

SPONSORS

Reichhold UK Ltd
54 Willow Lane
Mitcham
Surrey CR4 4NA
Tel: 020 8648 4684 Fax: 020 8640 6432
Web: www.reichhold.com

The Rooflight Company
Wychwood Business Centre
Shipton-under-Wychwood OX7 6XU
Tel: 01933 833108 Fax: 01993 831066
Web: www.therooflightcompany.co.uk

Büfa Composite Systems GmbH & Co.KG
Hone Looge 2-8. 26180 Rastede.
Germany
Tel: 07876 030296

SECRETARIAT

Lorraine Cookham
43, Clare Croft
Middleton
Milton Keynes
MK10 9HD
Tel: 01908 692325 Fax: 01908 674122
Mobile: 07989 872 149
Email: admin@narm.org.uk
Web: www.narm.org.uk

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NARM Secretariat
43 Clare Croft, Middleton
Milton Keynes MK10 9HD

Tel: +44 (0)1908 692325
Email: admin@narm.org.uk

www.narm.org.uk

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