Lighting extracts from the 'Determination method of the characteristic annual primary energy consumption of offices and schools' of the Belgian EPB-regulations

Status: fall 2011

Contents

Introduction

In Belgium each of the 3 Regions, i.e. Flanders, Wallonia and Brussels, are individually in charge of their own regulation on the energy performance of buildings. The calculation procedure for the determination of the energy performance of offices and schools is quasi identical in the 3 regions. In this procedure the energy consumption of lighting is considered. In the present document the parts of this procedure that concern lighting are translated into English. It concerns the most recent version of the text as of the fall of 2011, as already published by the Flemish and Brussels regions, and as anticipated to be published by the Walloon region.

The conventional electricity consumption is determined in chapter 9. In chapter 10 (not translated and not part of this document) the electricity consumption for lighting is converted into a primary energy consumption by multiplication with a fixed conversion factor. Next, this primary lighting consumption is added to the primary consumptions for heating, cooling and auxiliaries, and, the case being, the equivalent primary savings of electricity generated by photovoltaic systems or polygeneration are deducted. This overall total is the characteristic annual primary energy consumption of the office or school. In chapter 4 (see below) the ratio is taken with a reference value, and multiplied by 100. This is the definition of the E-level. The regulation imposes a maximum value for the E-level.

Like the French RT 2000 energy performance regulation, the Flemish method is based on the Dutch standard NEN 2916:1998, with some modifications. Most of these are minor and do not alter the underlying philosophy.

An addition in the Flemish procedure concerns the parasitic power consumption of sensing and control devices (presence detection, daylight dimming, etc.). Since this consumption can sometimes be very important (there are reported cases of 7W per detector), its inclusion in the calculated energy consumption will steer designers towards low power solutions. However, due to practical implementation issues (availability of correct input data, etc.) this aspect has been inactivated until further notice.

There is 1 other major addition: the approximate illuminances on the work plane that are achieved throughout the building are taken into account when determining the reference value for the characteristic annual primary energy consumption (and thus for the imposed maximum consumption). This means that, if less installed lighting results in lower illuminances, the maximum allowable energy consumption lowers, and the lighting must thus not be less efficient. In other words, one cannot more easily fulfil the energy performance requirements by simply installing less lighting (which may be too little to achieve the visual comfort requirements).

The method to approximately determine the illuminance (auxiliary variable L, see $9.4.2.2) is the result of extensive consultation with lighting companies active in Belgium. In the course of time, 3 different methods of varying complexity have been considered. The one finally selected was proposed by a member of the industry. It combines simplicity with reasonable accuracy, without inducing a benefit for optically undesirable luminaires.

The light flux leaving the luminaire is split up in 3 parts:

- one flow with a downward direction, within an angle of 60° with respect to the vertical. It is assumed that this light fully reaches the working plane (wall effects are neglected).
- the remainder of the downward flow (outside an angle of 60° with respect to the vertical) is not taken into consideration. This light may in many applications cause visual discomfort (direct blinding, reflections on screens, etc.). With the present method, no undesired incentive is given for visually undesirable types of luminaires, even if they may be -strictly energetically speaking- more efficient. This was a drawback of an initial proposal.
- the upward flux is multiplied with a fixed reduction factor of 0.5 to take account of the reflections on ceiling and walls, before reaching the working plane.

The formula makes use of the flux code as defined in the longstanding CIE publication[1] #52 (1982). This is a set of 5 numbers (varying between 0 and 100) that characterise the flux distribution of a luminaire. Once the flux distribution of a luminaire is measured, the flux code can immediately be calculated. It does not require any additional testing with respect to the standard luminaire characterisations that are already done.

The determination of the auxiliary variable L is thus independent of room shape, surface colours, furniture, etc. It merely results from the number of installed luminaires and their product properties, related to the floor area.

The flux code is defined as follows:

.N1 = FC1/FC4

.N2 = FC2/FC4

.N3 = FC3/FC4

.N4 = FC4/F

.N5 = F/PHIS

where:

FC1, FC2, FC3, FC4 and F are the luminous flows with respect to the vertical downward axis within solid angles of $\pi/2$, π, $3\pi/2$, 2π and 4π.

PHIS is the sum of the fluxes of the individual lamps in the luminaire. .N5 gives the total luminaire efficiency.

See also the figures below which follow CIE #52. For reporting the flux code, the values are multiplied by 100 and the dot in front of the symbol is omitted.

[1] "Calculations for interior lighting. Applied method."

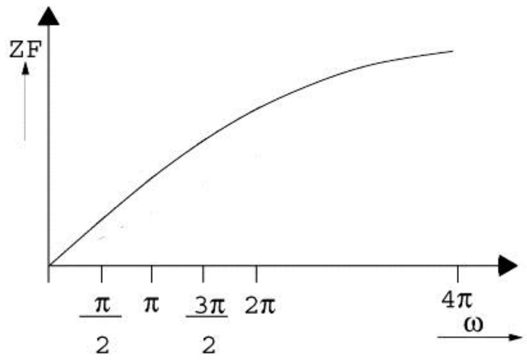

Figure 1: Illustration of a zonal flux diagram

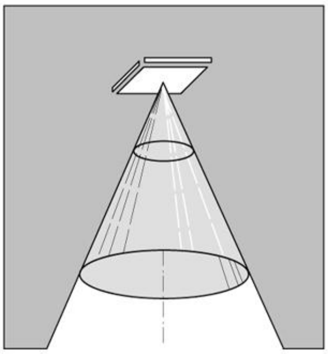

Figure 2: Sketch of a right cone with a solid angle ω about the vertical axis

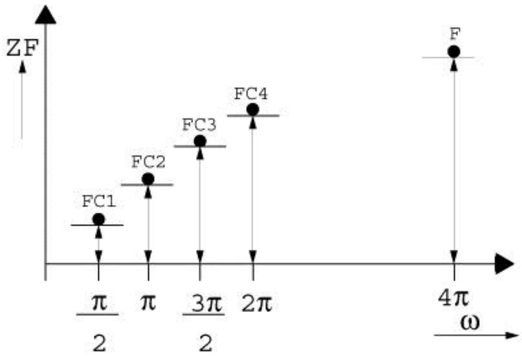

Figure 3: Plots of the 5 characteristic zonal flux values

Alternative to the standard (simplified) calculations, it is always permitted to perform detailed lighting calculations and use the illuminance thus found as value for the auxiliary variable L. This method also allows to take account of wall luminaires.

4. The level of primary energy consumption

The level of primary energy consumption of the ´EPU volume´ is given by the ratio of the characteristic annual primary energy consumption of the ´EPU volume´ to a reference value, multiplied by 100:

$$E = 100 \cdot \frac{E_{charannprimencons}}{E_{charannprimencons,ref}}$$

in which:

E	the level of primary energy consumption of the ´EPU volume´;
$E_{char\ ann\ prim\ en\ cons}$	the characteristic annual primary energy consumption of the ´EPU volume´, calculated according to 10.2, in MJ;
$E_{char\ ann\ prim\ en\ cons,ref}$	the reference value for the characteristic annual primary energy consumption, in MJ.

The result must be rounded off upwards to 1 unit.

The reference value for the characteristic annual primary energy consumption is given by:

$$E_{charannprimencons,ref} = b_1 \times A_f + b_2 \times A_{T,E} + b_3 \times \sum_r \dot{V}_{supply,min,rmr} + b_4 \times \sum_r \left(\dot{V}_{supply,rmr} - \dot{V}_{supply,min,rmr}\right) + b_5 \times 10^{-3} \times \sum_r \left[L_{rmr}^{0.8} \times \left(t_{day} + t_{night}\right) \times A_{f,rmr}\right]$$

in which:

b_1, b_2, b_3, b_4, b_5	constants as established in the main text of this decree;
A_f	the total floor area of the ´EPU volume´, in m²;
$A_{T,E}$	the total area of all separation structures which envelop the 'EPU volume' and through which transmission losses are considered within the determination of the energy performances[2] (See 3.2), in m²;
$\dot{V}_{supply,rmr,min}$	the minimal design supply flow rate of external air in room r, as imposed by this order, in accordance with the assigned design occupancy, in the assumption that there is no smoking and that the building is not very polluted,

[2] Thus, any structure which forms the separation between the 'EPU volume' and other adjacent heated rooms, is not considered in the calculation of $A_{T,E}$

in m³/h. If it concerns a special room as mentioned in 6.4 of annex X of this order, $\dot{V}_{supply, min, rm\ r}$ is taken equal to $\dot{V}_{supply, rm\ r}$;

$\dot{V}_{supply,rm\ r}$ the design supply flow rate of external air in room r for which the installation is designed, and as used in the calculation in 5.5, in m³/h;

L_{rm_r} a dimensionless auxiliary variable for room r, as specified in 9.3;

t_{day} the conventionally established number of day time operating hours of the lighting per year for the energy sector in which the room is situated, taken from Table 17 of 9.4.3, in h;

t_{night} the conventionally established number of night time operating hours of the lighting per year for the energy sector in which the room is situated, taken from Table 17 of 9.4.3, in h;

A_{f,rm_r} the floor area of room r, as used in 9, in m².

One must sum up over all the rooms r of the 'EPU volume'.

9. Energy consumption for lighting

9.1 Principle

In this chapter is the conventional electricity consumption for lighting determined. The conversion of electricity consumption to primary energy consumption is done in 10.5.

Only the fixed lighting within the ´EPU volume´ is included in the calculation. The way the building is divided up and the determination of the ´EPU volume´ with its possible subdivision into energy sectors are described in 3.

Possible examples of lighting outside the ´EPU volume´ can be (depending on the building in question):

- outdoor lighting
- interior lighting in spaces outside the protected volume
- lighting in residential parts of the building
- lighting in other spaces within the protected volume for which no EPU calculation must be performed.

Within the ´EPU volume´ are the following forms of lighting not considered:

- ´loose´ lighting: by this is intended loose devices which are connected by the user with a plug via a socket outlet to the electricity network, e.g. desk lamps, certain lamps which are fastened to the frame of paintings, etc.
- lamps for emergency exit direction indicators (and which are often permanently switched on)
- emergency lighting (as long as they are only switched on as necessary)
- lighting in elevator cars and elevator shafts

The consumption of batteries in lighting systems (e.g. in wireless switches) is not taken into consideration when determining the E-level.

According to 3.3, the ´EPU volume´ is divided into 1 or more energy sectors. The electricity consumption for lighting is the sum of the consumption of each of the sectors, see 9.2. Per energy sector, is the electricity consumption for lighting determined following 1 of the two following ways:

- on the basis of default values (9.3);
- on the basis of the actually installed power, whereby the following factors are taken into consideration:

- the type of control
- the number of -conventionally fixed- operating hours
- the power of the installed lamps including ballasts and alike, and the power of possible sensors and controls
- the possible presence of a daylight zone with appropriate control
-

If there is no fixed lighting in a room, than is the calculation, in this room, performed on the basis of steady prescribed values. Those values are taken equal to those used for the calculation with default values, in case of fixes lighting.

The calculation is performed as follows:

1. Take the division into energy sectors as intended in 3.2.2. Per energy sector, the electricity consumption for lighting is individually determined.

2. Decide per energy sector whether the electricity consumption will be determined on the basis of the actually installed power (9.4) or on the basis of set values (9.3). The choice for the one or the other method is completely free. In order to calculate on the basis of the actually installed power, the necessary product characteristics of the lamps, fittings and so on, must be introduced.

3. If one calculates on the basis of the actually installed power : divide each energy sector into rooms.

If in 1 or several rooms no fixed lighting is installed, then this/these room(s) forms a separate room where one must calculate conventionally with fixed prescribed values (These are taken to be equal to the values used for the calculation on the basis of the set values in the event that there is lighting there).

9.2 Total electricity consumption for lighting

The annual electricity consumption for lighting of the ´EPU volume´, is the sum of electricity consumptions for lighting of each of the energy sectors, plus the possible electricity consumption of all controls units, and alike, which are outside the 'EPU volume' but are in charge of lighting inside the 'EPU volume':

$$W_{light} = \sum_i W_{light,\sec i} + \sum_r W_{light,rm\_r,ctrl}$$

in which:

W_{light} the annual electricity consumption for lighting in kWh;

$W_{light,sec\ i}$ the annual electricity consumption for lighting of energy sector i in kWh, determined following 9.3 or 9.4.

$W_{light,rm\_r,ctrl}$ the annual electricity consumption for control apparatus, and alike, which are situated outside the 'EPU volume' but serve lighting inside the 'EPU volume', in kWh, determined following 9.4.3.3.3.

One must sum up over all energy sectors i of the 'EPU volume' and over all the rooms r outside the 'EPU volume'.

9.3 Electricity consumption for lighting on the basis of default values

Take, for the auxiliary variable L, - which is necessary for determining the reference value for the annual primary energy consumption (4) - the value:

$$L_{rm\_r} = 500$$

Determine the electricity consumption for lighting, including the possible consumption of control systems, of the energy sector with:

$$W_{light,\sec i} = \sum_r A_{f,rm\_r} \times p_{light,def} \times (t_{day} + t_{night})$$

in which:

$W_{light,sec\ i}$ the electricity consumption for lighting in energy sector i, in kWh;

A_{f,rm_r} the floor area in room r, in m²;

$p_{light,def}$ the set value of the specific power for lighting.
Take: $p_{light,def} = 0.020$ kW/m²

t_{day} the conventionally fixed number of day time operating hours per year, taken from Table 15, in h;

t_{night} the conventionally fixed number of night time operating hours per year, taken from Table 15, in h.

The summation must done over all rooms of the energy sector i.

Set the value equal to 0 for the annual electricity consumption for control apparatuses, and alike, that are situated outside the 'EPU volume' and only serve luminaires in rooms in the considered energy sector:

$$\sum_{r} W_{light,rm\,r,ctrl} = 0$$

in which:

$W_{light,rm\,r,ctrl}$ the annual electricity consumption for control apparatus, and alike, that are situated outside the 'EPU volume' and only serve luminaires in rooms in the considered energy sector i, in kWh.

If the control apparatus also serve other luminaires in other energy sectors and if for these energy sectors the electricity consumption for lighting is determined by means of the actually installed power, then their consumption must be included in 9.4.3.3.3.

9.4 Electricity consumption for lighting on the basis of the actually installed power

9.4.1 Principle

First determine for each room an auxiliary variable L_{rm_r} (9.4.2). This is an approximate measure for the average lighting level. It defines, together with other parameters, the reference value for the characteristic primary energy consumption (4). It is also used to determine the lowered calculation value of the installed power in the event of an adjustable lighting intensity (9.4.4). The auxiliary variable L_{rm_r} can be determined following 2 ways:

- either by means of an easy, conventional method (9.4.2.2);
- or by means of detailed calculations (9.4.2.3).

For most applications the first method can suffice. In the conventional method, certain types of luminaires (see 9.4.2.2) don't contribute to the auxiliary variable L (but their electrical consumption is always obligatorily included in the calculation! see 9.4.3). If desired, one can in these cases revert to the second method to calculate the contribution to $L_{rm\ r}$.

Then, determine for each room the electricity consumption for lighting as the product of the installed lighting capacities, including possible chokes and controls, and the time that the lighting per year is turned on, taking into account the switches and/or controls which are present. Add to this the electricity consumption of the controls in so far as it was still not included in the calculation in the previous term. The incoming transmission of daylight can, if the part near the facade is separately dimmable, be valued, depending on the glass area in the facade and the visual transmission of the glazing. For this, divide the room in a conventional manner into an artificial light area and a daylight area following 9.4.5.

9.4.2 Determination of the auxiliary variable $L_{rm\ r}$

9.4.2.1 Determination of the auxiliary variable L_{rm_r} in rooms without fixed installed lighting installation.

Take, in the room where no fixed lighting is installed, conventionally the value:

$L_{rm\ r} = 500$

9.4.2.2 Determination of the auxiliary variable L_{rm_r} in the conventional manner

Determine the auxiliary variable L_{rm_r} for the room r:

$$L_{rm\_r} = \frac{\sum_k n_k \times 0.85 \times PHIS_k \times .N5_k \times [.N2_k \times .N4_k + 0.5 \times (1 - .N4_k)]}{A_{f,room\_r}}$$

in which:

L_{rm_r} a dimensionless auxiliary variable for room r;

n_k the number of fittings of type k in the room;

$PHIS_k$ the sum of the light current of each of the lamps in the fitting of type k, in lumen:

$$PHIS_k = \sum_m PHI_m$$

with:

PHI_m the light current of lamp m, determined following CIE 84, in lumen;

whereby one sums up over all lamps m which are in the fitting of type k

$.N5_k$	the ratio of the total light flux which leaves the fitting k to the light flux ($PHIS_k$) emitted by all lamps together in the fitting (-), determined following CIE 52;
$.N4_k$	the ratio of the light flux which leaves the fitting k in a solid angle of 2π vis-à-vis the main axis (i.e. in a cone with aperture angle of 180°) to the total outgoing flux of the fitting (-), determined following CIE 52;
$.N2_k$	the ratio of the light flux which leaves the fitting k in a solid angle of π vis-à-vis the main axis (i.e. in a cone with aperture angle of 120°) to the light flux which leaves the fitting k in a solid angle of 2π vis-à-vis the main axis (-), determined following CIE 52;
$A_{f,seci,zonej}$	the floor area of the room r, in m^2.

If for a specific fitting/lamp combination the necessary data are not available, they are left out of consideration in the determination of the auxiliary variable L. (But its consumption must obligatorily be included in the calculation in 9.4.3!)

One sums up over all types of ceiling fitting k (recessed, surface mounted or suspended fittings) which are present in the room. Wall fittings and lighting which is built into the floor or in staircases must be included in the calculation of the installed power, see 9.4.3 (and thus ultimately in the characteristic primary consumption), but not in the determination of the auxiliary variable L_{rm_r} according to the conventional method. If one does want to include other than ceiling fittings in the determination of the auxiliary variable L_{rm_r}, then one must use the detailed method of calculation, see following section (9.4.2.3)

Ceiling fittings which are installed in such a way that the main axis is not oriented vertically downwards (e.g. against a sloped roof) or which are orientable (e.g. rotatable spotlights), are only included in the conventional method for determining the auxiliary variable L_{rm_r} in so far as the main axis deviates no more than 45° from the vertical or in the event of revolving fittings, can never deviate more than 45° from the vertical (in its most unfavourable position). The main axis is the same as that which is used for determining the flux code. If this restriction qua installation is not satisfied, such fittings are not including in the determination of the auxiliary variable L_{rm_r} according to the conventional method, but they must be included in the determination of the energy consumption. If one nevertheless does wish to include these fittings in the calculation determining the auxiliary variable L_{rm_r}, then one must use the detailed calculation method, see following section (9.4.2.3)

9.4.2.3 *Determination of the auxiliary variable L_{rm_r} by means of detailed calculations*

As alternative to the conventional calculation method, it is allowed to calculate for a room with a calculating program the illuminance on a notional plane at a height of 0.8m. The auxiliary variable L_{rm_r} is then taken equal to the average illuminance (expressed in lux). The average is taken over the entire area of the room, thus without any deduction of peripheral or other zones. One must calculate with the real geometry of the (empty) space (without furniture). The reflection coefficients to be used are: 0.7 for the ceiling, 0.5 for the walls (including daylight openings) and 0.2 for the floor. For the calculations, the same position must be taken for the fittings as the actual installation. In the event of orientable fittings, for the calculations the fitting must be oriented in such a way that the angle between the main axis and the vertical axis is as great as possible (thus maximally oriented upwards). If then various orientations are still possible, the fitting must be oriented perpendicular to the nearest wall. For the light flux of the lamps, an unchangeable reduction factor of 0.85 must be retained vis-à-vis the CIE 84 value. The minister can fix additional specifications (or refer to other ones) for the calculation.

The auxiliary variable L_{rm_r} is equated to the average on the notional plane in the room, calculated by convention for the entire area of the empty room.

The program that is used for the calculation must be approved in advance by the minister.

9.4.3 Determination of the electricity consumption per energy sector.

9.4.3.1 Electricity consumption for lighting per energy sector

Determine the electricity consumption for lighting of an energy sector as the sum of the electricity consumption for lighting of each of the rooms in this energy sector:

$$W_{light,\sec i} = \sum_{j} W_{light,rm\,r}$$

in which:

$W_{light,sec\ i}$ the electricity consumption for lighting of energy sector i, in kWh;

W_{light,rm_r} the electricity consumption for lighting of room r in energy sector i in kWh, determined following 9.4.3.2 or 9.4.3.3.

One must sum up over all rooms r of energy sector i.

9.4.3.2 Electricity consumption for lighting in a room without fixed installed lighting installation

In rooms without fixed lighting installation, the calculation value for the annual electricity consumption conventionally amounts to:

$$W_{light,rm\,r} = A_{f,room\_r} \times p_{light,abs} \times \left(t_{day} + t_{night}\right)$$

in which:

$W_{light,sec\ i,rm\_r}$ the electricity consumption for lighting of room r in energy sector i, in kWh;

A_{f,rm_r} the total floor area of the room where no fixed lighting is installed, in m²;

$p_{light,abs}$ a fixed value for the specific power for lighting. Take: $p_{light,abs}$ = 0.020 kW/m²

t_{day} the conventionally fixed number of day time operating hours per year, taken from Table 17, in h;

t_{night} the conventionally fixed number of night time operating hours per year, taken from Table 17, in h.

9.4.3.3 Electricity consumption for lighting in a room with a fixed installed lighting installation

Determine, in the event that a lighting installation is present, the annual electricity consumption for lighting per room by summing up the total electricity consumption for the daylight and artificial light areas and for the possible control, in so far as this last consumption is not yet included in the consumption of the fittings during the operating hours, with:

$$W_{light,rm\,r} = W_{light,rm\,r,artif\,area} + W_{light,rm\,r,dayl\,area} + W_{light,rm\,r,ctrl}$$

in which:

W_{light,rm_r}	the electricity consumption for lighting of room r in energy sector i, in kWh;
$W_{light,rm\_r,artif\ area}$	the electricity consumption in the artificial light area of the considered room r, determined following 9.4.3.3.1, in kWh;
$W_{light,rm\_r,dayl\ area}$	the electricity consumption in the daylight area of the considered room r, determined following 9.4.3.3.2, in kWh;
$W_{light,rm\_r,ctrl}$	the electricity consumption of the control that is not yet included in the calculation in the two previous terms, determined following 9.4.3.3.3, in kWh.

9.4.3.3.1 Electricity consumption of an artificial light area

Determine for the artificial light area of a room the annual electricity consumption with:

$$W_{light,rm\,r,artif\,area} = P_{light,rm\,r} \times \frac{A_{f,rm\,r,artif\,area}}{A_{f,rm\,r}} \times f_{switch} \times f_{\text{mod},artif} \times (t_{day} + t_{night})$$

in which:

$W_{light,rm\_r,artif\ area}$	the electricity consumption in the artificial light area of the considered room r, in kWh;
P_{light,rm_r}	the calculation value for the power for lighting in the entire room r, determined following 9.4.4, in kW;
$A_{f,rm\_r,artif\ area}$	the floor area of the artificial light area in the room r, determined following 9.4.5, in m²;
A_{f,rm_r}	the floor area of the room r, in m²;
f_{switch}	the factor for the switching control system, taken from Table 15;
$f_{mod,artif}$	the factor for the modulating control system in the artificial light area, taken from Table 16;
t_{day}	the conventionally fixed number of day time operating hours per year, taken from Table 17, in h;
t_{night}	the conventionally fixed number of night time operating hours per year, taken from Table 17, in h.

If, in a room, different kind of switch and/or, in the artificial area of the room, different kind of dimming systems are present, than must the calculation be made with the highest value of the applicable factors f.

Table 15 : Factor for switching control systems

DESCRIPTION OF SWITCHING	f_{switch}
Central on/off[3] and all other systems not metioned below	1.00
Manual switching[4]	max [0.90; min(1.00; 0.90+0.10*(A_s-8)/22)]
Presence detection: switches both automatically on and automatically off or to a dimmed state (auto on; auto off/dim)	
• largest controlled area A_s < 30 m²	
• if complete switching off in absentia:	0.80
• if switch back to a dimmed state in absentia:	0.90
• largest controlled area A_s ≥ 30 m²	1.00
Manual switching on; absence detection switches automatically off or to a dimmed state (manual on; auto off/dimmed)	
• largest controlled area A_s < 30 m²	
• if complete switching-off in absentia:	0.70
• if switch back to a dimmed state in absentia:	0.85
• largest controlled area A_s ≥ 30 m²	1.00

in which:

A_s the largest controlled area which is switched by 1 sensor in the room, as further described below, in m².

One is not obliged to state the value for A_s. In that event, 1.00 is the default value for f_{switch}.

The area switched by means of a manual switch and/or by a sensor for presence and/or absence detection is the total floor area lighted by all fittings which together are regulated by this switch or sensor. The delineation of the area between fittings that are switched separately is conventionally formed by the axial lines between 2 fittings. Per room must the largest “switched” area A_s (expressed in m²) be considered to determine the switch reduction factor. The calculation value of A_s to be used must be

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[3] As soon as a switch controls the lighting in more than 1 room, the switch is considered as 'central';

[4] This expression gives the value 0.9 for A_s smaller than 8m² and the value 1.0 for A_s greater than 30m². In between these the value varies linearly.

rounded off upwards to a whole number of m². The "switched" areas can differ from the areas controlled by daylight dimming (see below).

Table 16 : Factor for modulating control systems

Description of modulating control	$f_{mod,dayl}$	$f_{mod,artif}$
No dimming	1.0	1.0
Daylight dimming[5]	max[0.6; min(1.0; 0.6+0.4*(A_m - 8)/22)]	max[0.8; min(1.0; 0.8+0.2*(A_m - 8)/22)]

in which:

A_m the largest controlled area which is dimmed by 1 sensor in the room as further described below, in m².

One is not obliged to state the value for A_m. In that event, 1.00 is the default value for $f_{mod,dayl/artif}$.

By daylight dimming is understood here systems with light sensors which decrease the light current of the lamp(s) fully automatically and in a continually variable manner as more daylight becomes available.

The area that is dimmed by a sensor is the total floor area, which is lighted by all fittings which are controlled by this sensor. The delineation of the area between fittings with different sensors is conventionally formed by the axial lines between 2 fittings. Per room must the largest area A_m (expressed in m²) be considered to determine the modulating reduction factor. The calculation value of A_m to be used must be rounded off upwards to a whole number of m². The area of the dimming does not have to coincide with that of the switches (see above).

Table 17 : Conventionally fixed computational value for the operating time per year during the day t_{day} and at night t_{night}

Destination	Day time operating time t_{day} (h)	Night time operating time t_{night} (h)
Office School	2200	150

[5] This expression gives the minimal value (0.6 or 0.8) for A_m smaller than 8m² and the maximum value 1.0 for A_m greater than 30m². In between these the value varies linearly.

9.4.3.3.2 Electricity consumption of a daylight area

Determine the annual electricity consumption of a daylight area of a room, if it is equipped with a daylight-dependent control or switch, with:

$$W_{light,rm\,r,daylarea} = P_{light,rm\,r} \times \frac{A_{f,rm\,r,daylarea}}{A_{f,rm\,r}} \times f_{switch} \times (f_{mod,dayl} \times t_{day} + f_{mod,artif} \times t_{night})$$

in which:

$W_{light,rm\_r,dayl\ area}$	the electricity consumption in the daylight area of the considered room r, in kWh;
P_{light,rm_r}	the calculation value for power for lighting in the entire room, determined following 9.4.4, in kW;
$A_{f,rm\_r,dayl\ area}$	the floor area of the daylight sector in the room r, determined in accordance with 9.4.5, in m²;
A_{f,rm_r}	the floor area of the room r, in m²;
t_{day}	the number of day time operating hours per year, taken from Table 17, in h;
t_{night}	the number of night time operating hours per year, taken from Table 17, in h;
f_{switch}	the factor for the switching control system, taken from Table 15;
$f_{mod,dayl}$	the factor for the modulating control system in the daylight area, taken from Table 16;
$f_{mod,artif}$	the factor for the modulating control system in the artificial light area, taken from Table 16.

If, in a room, different kind of switch and/or, in the daylight area of the room, different dimming systems are present, than must the calculation be made with the highest value of the applicable factors f.

9.4.3.3.3 Electricity consumption for the control equipment that is not yet included in the consumption of the fittings[6]

Determine, per room, the annual electricity consumption for the control equipment and alike (considering possible ballasts, sensors and/of switches), in so far as not yet included in the consumption of the fittings during the operating hours, with:

$$W_{light,rm\,r,ctrl} = \sum_k \Big[\Big(P_{light,rm\,r,ctrl,on,k} \times f_{switch} \times (t_{day} + t_{night}) \Big) + P_{light,rm\,r,ctrl,off,k} \times \big(8760 - f_{switch} \times (t_{day} + t_{night})\big) \Big] / 1000$$

[6] The parasitic consumption of lighting installations is not yet considered at the entering into force of this order. This paragraph only becomes operational at a date to be specified by the minister.In the mean calculations are done with $W_{light,rm\,r,ctrl}$ = 0 kWh.

in which:

$W_{light,rm\_r,ctrl}$ the annual electricity consumption of the control that is not yet included in the consumption determined following 9.4.3.3.1 and 9.4.3.3.2, in kWh;

$P_{light,rm\_r,ctrl,on,k}$ the power of supply k of the (group of) controls (considering the possible controls, sensors and/or switches) during the operating hours that is not yet included in the power of the fittings, in W;
The default value for each supply of control apparatus, switches, sensors (whether or not integrated in the luminaire), etc. 3 W per luminaire that is served by the device;

$P_{light,rm\_r,ctrl,out}$ the power of supply k of the (group of) controls (considering the possible control, sensors and/or switches) outside the operating hours
The default value for each supply of control apparatus, switches, sensors (whether or not integrated in the luminaire), etc. 3 W per luminaire that is served by the device;

f_{switch} the switch factor which applies, taken from Table 15;

t_{day} the number of day time operating hours per year, taken from Table 17, in h;

t_{night} the number of night time operating hours per year, taken from Table 17, in h.

If a control k serves several rooms, then is f_{switch} taken equal to the maximal value calculated among the concerned rooms.

One must sum up over all supplies k, that are situated in the room r.

9.4.4 Calculation value for the power per room

First determine, per room, the calculation value for the nominal power by summing up the powers of all light fittings (lamps including possible chokes, sensors and controls), with:

$$P_{nom,rom\_r} = \frac{\sum_k P_{fitting,k}}{1000}$$

in which:

P_{nom,rm_r} the calculation value for the nominal power of all lamps including possible chokes, sensors, controls and/or switches in the room r, in kW;

$P_{fitting,k}$ the calculation value for the power of (all) lamp(s) including possible chokes, sensors, controls and/or switches of light fitting k, in W.

One must sum up over all fittings k in the room r.

1. Take as calculation value for the lighting power if the desired lighting intensity is not adjustable:

$$P_{light,rm\ r} = P_{nom,rm\ r}$$

in which:

$P_{light,rm\ r}$	the calculation value for the power, in kW;
$P_{nom,rmr}$	the calculation value for the nominal power as defined above, in kW.

2. If the desired lighting intensity is quite freely adjustable (either fitting per fitting, or per group of fittings), and this for all fittings in the room r, then conventionally one uses the following calculation value for the lighting power[7]:

$$P_{light,rm\,r} = P_{nom,rm\,r} \times \min\left(1, \frac{L_{thresh} + f_{reduc} \times (L_{rm\,r} - L_{thresh})}{L_{rm\,r}}\right)$$

in which:

P_{light,rm_r}	the calculation value for the power, in kW;
P_{nom,rm_r}	the calculation value for the nominal power as defined above, in kW;
L_{rm_r}	auxiliary variable, determined following 9.4.2;
f_{reduc}	reduction factor with as value: $f_{reduc} = 0.5$
L_{thresh}	threshold value for L, with as value: $L_{thresh} = 250$

9.4.5 Division into daylight and artificial light area

If the daylight area is separately dimmable, a lower electricity consumption can be included in the calculation (see 9.4.3.3.2 and Table 16).

One is not obliged to include this effect in the calculation. In this case, one takes $A_{f,rm\_r,dayl\ area} = 0$.

In the other case, one must, on the basis of the daylight openings, determine the daylight area. The daylight area is conventionally defined as the zone where the daylight factor on the (notional) work plane (at 0.8m above the finished floor) amounts to 3%. If desired, this can be determined in a detailed way (9.4.5.1), or in a conventional manner(9.4.5.2).

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[7] If $L_{rm\ r}$ equals zero (e.g. because no data of the installed luminaires have been made available) $P_{light,rm\ r} = P_{nom,rm\ r}$.

9.4.5.1 Detailed method

If use is made of a detailed method, the following conventions must be respected:

- For the glazing, the real characteristics must be used (visual transmission, geometry, including the geometry of the frame profile, etc.)
- For the space, the real geometry in an empty state (without furniture) must be used. The reflection coefficients to be used are: 0.7 for the ceiling, 0.5 for all opaque wall parts (including the window profiles) and 0.2 for the floor. For the glazing, the real values for transmission must be used.
- The minister can fix additional or modified specifications.

The detailed method (calculation program) must be recognised by the minister in advance.

9.4.5.2 Conventional, simplified method

A first contribution to the daylight area is formed by the vertical projection onto the floor area of inwardly-inclined and horizontal daylight openings (e.g. skylights). A second contribution is made by vertical daylight openings and by the equivalent vertical openings of inclined windows. For this, each inclined window is projected onto a vertical plane which goes through the uppermost edge of the window (see Figure 5). The precise determination of both contributions is performed following 9.4.5.2.1 and 9.4.5.2.2.

Overlapping parts are subtracted in order to determine the total daylight area:

$$A_{f,rm\ r,dayl\ area} = A_{f,rm\ r,dayl\ area,vert} + A_{f,rm\ r,dayl\ area,depth} - A_{f,rm\ r,overlap}$$

in which:

$A_{f,rm\_r,dayl\ area}$	the total floor area of the light area of the considered room r, in m²;
$A_{f,rm\_r,dayl\ area,vert}$	the floor area corresponding to the vertical projection of daylight openings, determined following 9.4.5.2.1, in m²;
$A_{f,rm\_r,dayl\ area,depth}$	the floor area of the contribution of the (equivalent) vertical daylight openings, determined following 9.4.5.2.2, in m²;
$A_{f,rm\_r,overlap}$	the floor area which satisfies both the conditions of 9.4.5.2.1 and those of 9.4.5.2.2, in m².

The artificial light area is the remaining area of the room r:

$$A_{f,rm\ r,artif\ area} = A_{f,rm\ r} - A_{f,rm\ r,dayl\ area}$$

in which:

$A_{f,rm\_r,artif\ area}$	the area of the artificial light area of the considered room r, in m²;
A_{f,rm_r}	the total floor area of the considered room r, in m²;
$A_{f,rm\_r,dayl\ area}$	the area of the daylight area of the considered room r as defined above, in m².

Conditions:

In determining the upper edge of the passage and the bottom of the passage of vertical daylight openings, the conditions indicated in Figure 4 must be satisfied. This means that the height of the lower edge of the daylight opening (transparent part of the window) with which one must calculate amounts to at least 0.8m, even if the real value is smaller. Analogously the height of the upper edge amounts to at most 4m. The heights are determined from the finished floor.

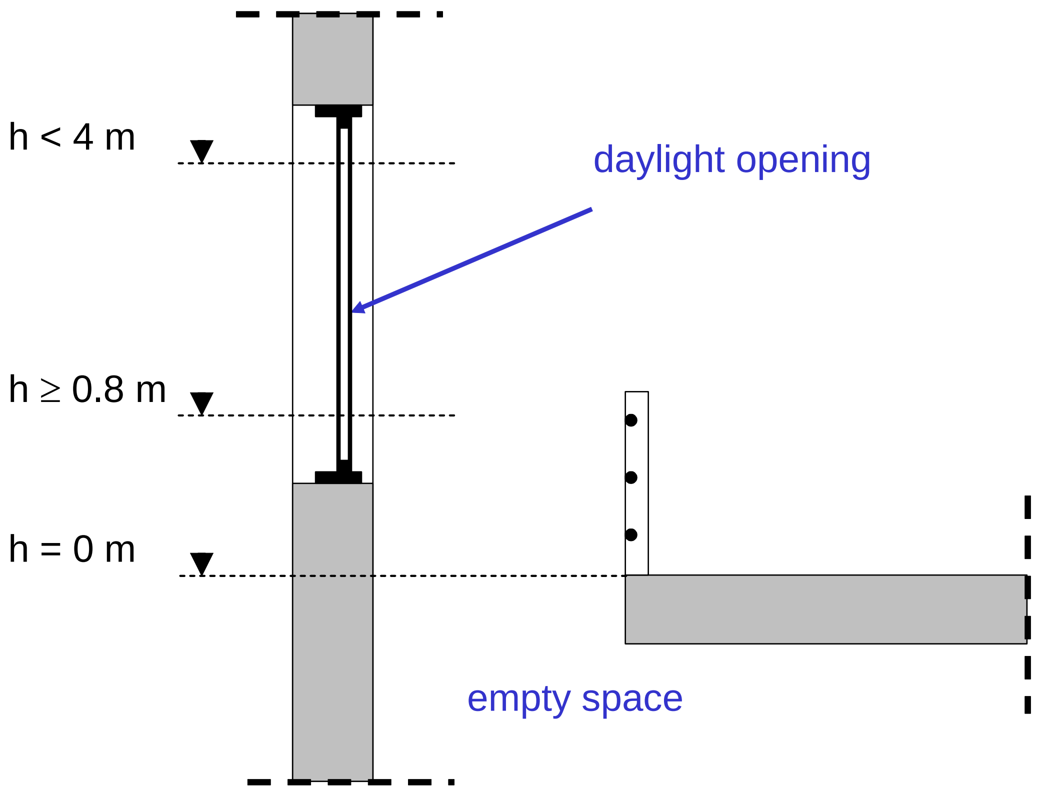

Figure 4 : Projection from the upper edge of the floor to the facade (e.g. with empty spaces) and limitation of the minimum and maximum height to be considered of the (equivalent) vertical daylight opening

9.4.5.2.1 Area contribution of the vertical projection of daylight openings

The contribution of horizontal and inwardly-inclined daylight openings[8] on the daylight area consists of the sum of the areas of the vertical projections of these daylight openings onto the underlying floor, in so far as located within the floor area of the energy sector, see Figure 2.

Determine this area per room with:

$$A_{f,rmr,daylarea,vert} = \sum_k A_{f,rmr,daylarea,vert,k}$$

in which:

$A_{f,rm\_r,dayl\ area,vert}$	the total area within a room r of the vertical projections of horizontal and inwardly-inclined daylight openings on underlying floor sections, in m²;
$A_{f,rm\_r,dayl\ area,vert,k}$	the area of the vertical projection of daylight opening k in so far as falling within the floor area, in m².

One must sum up over all daylight contributions k.

[8] The visual transmittance $\tau_{vis,dir,h}$ (normal incidence, hemispherical transmittance) of the transparent parts must be at least 60%. If not, that daylighting opening is not taken into consideration when determining the daylight zone.

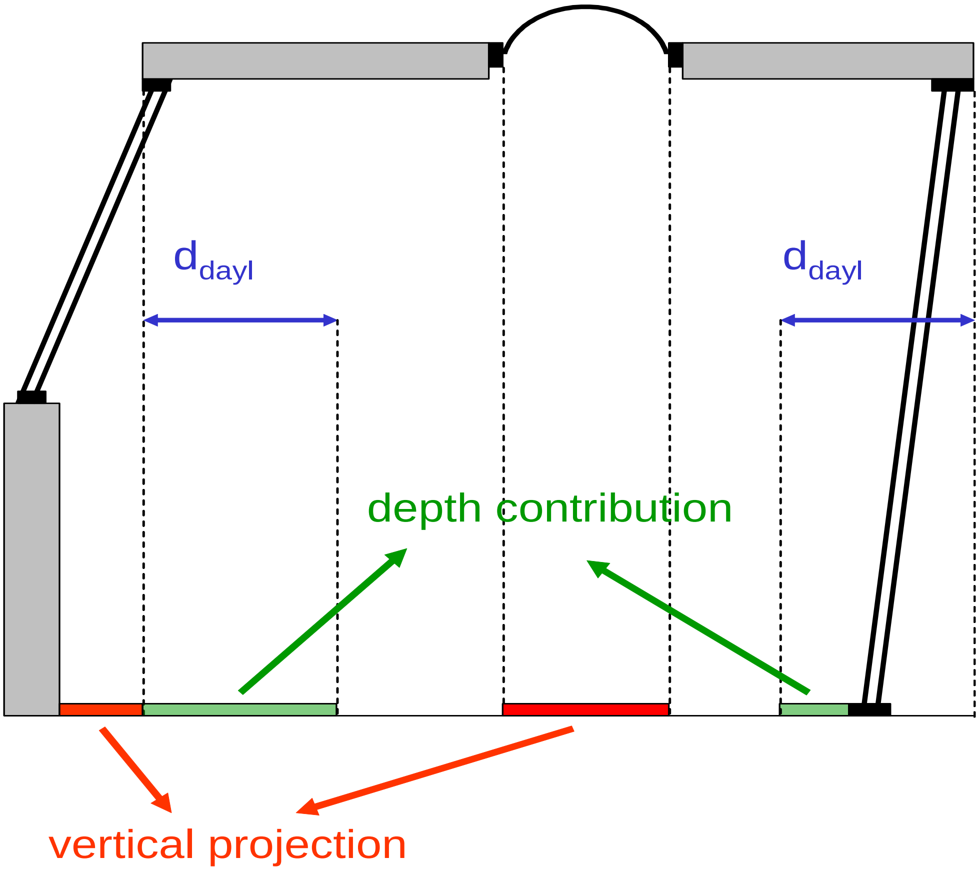

Figure 5 : Contributions of the vertical projection and the depth projection

9.4.5.2.2 Areacontribution of the (equivalent) vertical daylight openings

Determine the area contribution of (equivalent) vertical daylight openings as the sum of the areas obtained by multiplication of the length and the depth of the daylight area, in so far as located within the floor area of the room r, which satisfy the conditions for a contribution of the (equivalent) vertical daylight openings with:

$$A_{f,rmr,daylarea,depth} = \sum_k l_{dayl,k} \times d_{dayl,int,k}$$

in which:

$A_{f,rm\_r,dayl\ area,depth}$ the area of the contributions of the (equivalent) vertical daylight openings, in m²;

$l_{dayl,k}$ the facade length of the section of the daylight area belonging to daylight opening k determined following 9.4.5.2.2.1, in m;

$d_{dayl,int,k}$ the depth of the section of the daylight area belonging to daylight opening k which lies within the floor area, determined following 9.4.5.2.2.2, in m.

One must sum up over all daylight contributions k.

9.4.5.2.2.1 Daylight length l_{dayl}

Take as facade length of the daylight area belonging to a certain daylight opening the width of the passage (i.e. the transparent part) of the daylight opening on both sides increased by at most 0.5m (but not further than an adjacent supporting inner wall). Overlappings may not be double counted, see Figure 6.

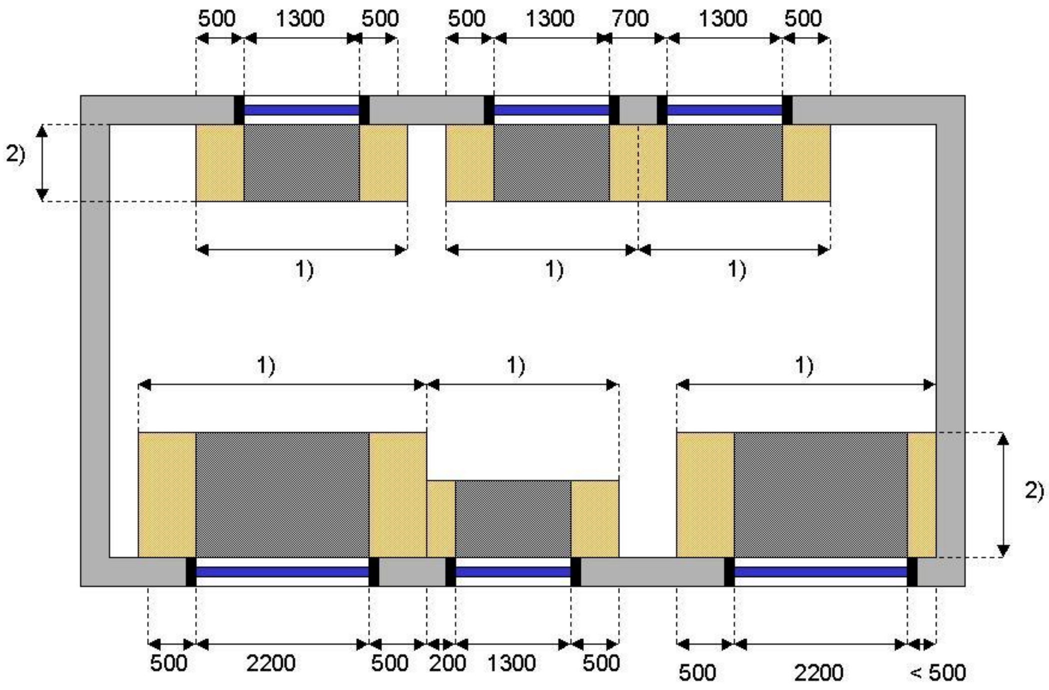

Figure 6 : Part of the floor area behind transparent and non-transparent facade parts that belongs to the daylight area

(In the figure different daylight depths are assumed)

1) l_{dayl}: daylight length

2) d_{dayl}: daylight depth

9.4.5.2.2.2 Daylight depth

Determine the daylight depth per (equivalent) vertical daylight opening as follows.

Take for inclined daylight openings the vertical plane that goes through the highest extreme (exterior) sides of the passage, however not higher than 4 m above the upper edge of the finished floor. Set the daylight depth at the site of the daylight opening, d_{dayl}, as defined below, inward from perpendicular onto the thus-defined vertical plane, or vis-à-vis the edge of the floor area in the event of a vertical daylight opening.

If the thus-obtained daylight area lies completely within the floor area, there applies:

$$d_{dayl,int} = d_{dayl}$$

Otherwise the total daylight depth must be reduced by the part that lies outside in order to obtain $d_{dayl,int}$ (see empty space in Figure 1 or right window in Figure 2).

The daylight depth, d_{dayl}, is given by:

1. If the numerical value of (h_o x τ_v) is less than 0.50, then there applies:

$$d_{dayl} = 0 \text{ m}$$

2. If the numerical value of (h_o x τ_v) is greater than or equal to 0.50, then there applies:

$$d_{dayl} = 0.5 + 3\ (h_o \times \tau_v)$$

in which:

d_{dayl} the depth of the daylight area belonging to the daylight opening, in m;
h_o the height of the passage of the daylight opening, in m;
τ_v the light transmittance $\tau_{vis,dir,h}$ (normal incidence, hemisferical transmittance) of the glazing, determined following NBN EN 410 (-).

The height of the passage, h_o, is given by:

$$h_o = u_o - l_o$$

in which:

h_o the height of the passage of the daylight opening, in m;
u_o the height of the upper edge of the passage above the finished floor, with a maximum of 4m, in m;

l_o the height of the lower edge of the passage above the finished floor, with a minimum of 0.8m, in m.

The depth of daylight area can never have a bigger value than the depth of the room r.