Daylighting by rooflights
Recommendations for design
to maximize the benefit of rooflights in buildings

Guideline 03: Issue September 2017

Whilst the information in this publication is correct at the time of going to press Eurolux and its member organisations assumes no responsibility or liability for any errors or inaccuracies that may appear in the content of this guide.

Developed by:
Expert group of EUROLUX

Publisher:
EUROLUX
Rue Washington 40,
B - 1050 Bruxelles

Contents

FOREWORD

"LUX VITA EST" - Daylight is life.

Daylight is the source of evolution of life. In general, the daily cycle of day and night plays a major role in controlling our circadian rhythms which regulate and maintain biochemical, physiological and behavioural processes in living beings. In addition there are biochemical reactions (photosynthesis) in plants, trees, algae, etc. …

The deficiency of natural daylight will lead to any living being withering sooner or later. Our body uses light as a nutrient for metabolic processes similar to food and water. For human beings, seasonal affective disorder (SAD) as well as sick building syndrome (SBS) are strongly suspected of being caused, directly or indirectly, by a lack of exposure to natural daylight. Human beings evolved from caves illuminated by the light of fire to buildings illuminated with natural daylight.

For many years daylight was the primary source for lighting buildings. Since the widespread use of artificial (especially electrical) lighting design criteria changed architectural design, sometimes the internal environment only, to make it more comfortable than outside, sometimes emphasising the desirability of natural materials

Today the goal is to construct "sustainable" buildings to reduce environmental impact. In this context, the daylight must be the primary source for lighting, as an integral part of the 'sustainable' building because daylight is free energy and it is assumed that a well-designed natural lighting system will reduce the use of electricity.

It should be stated, however, that besides energy saving natural light brings numerous benefits that can indirectly generate additional financial advantages.

The buildings are in fact built to perform tasks that require a lighting system that is not an end in itself but is a necessity, and it is intended to optimize the results. To achieve this goal, it is necessary that people can carry out their tasks in the best conditions that depend very much on the lighting system.

This guideline refers to buildings where specific activities are carried out for example:

- commercial activities, retail stores,
- industrial activities, factories,
- educational activities, schools, nursery schools,
- cultural activities, museums and galleries,
- administration work, offices,
- healthcare, hospitals, care homes,
- public transport, airports, railway and bus stations,
- sports activities, gymnasiums, sport stadiums, swimming pools,
- etc ...

These principles, valid for any natural lighting system, are enhanced in the case of rooflights which receive continuous and homogeneous daylight.

We can summarize the benefits of lighting through rooflights as follows:

- Daylight is good for health and well-being,
- Daylighting enhances the feeling of comfort,
- Daylight stimulates the human visual system,
- Improvement of environmental conditions enhances productivity,
- Daylighting increases the level of attention to improving safety in production activities,
- Daylighting increases the level of students attention increasing their performances (up to 25 %),
- Daylighting generates energy savings coming from the economy of electricity and from the heat gain in winter time,

- Shopping centres lit with rooflights noticed an increase in sales (up to 40%),
- Employees prefer to operate in daylit zones.

EUROLUX prepared this guideline to introduce all relevant issues for using rooflights for daylighting in buildings

This document is prepared by the main European experts with more than 20 years experience in the writing of the relevant standards.

1. Scope

This guideline specifies minimum recommendations for achieving an adequate light level and uniformity in buildings by means of natural light using rooflights.

This guideline specifies simple calculation methods for the design of the layout and installing of different types of rooflight assemblies to achieve the recommended level of lighting to fulfil specific visual task activities, to create a healthy and comfortable environment and to save energy in buildings.

This guideline applies to all spaces that may be regularly occupied by people for extended periods except where daylighting is contrary to the use or application of the space (for example darkrooms, cinemas, concert halls and theatres…).

2. Normative references

EN 410*, Glass in building - Determination of luminous and solar characteristics of glazing*

EN 12464-1:2011*, Light and lighting - Lighting of workplaces - Part 1: Indoor workplaces*

EN 12665:2011*, Lighting applications – Basic terms and criteria for specifying lighting requirements*

EN 15193-1:2014, *Energy performance of buildings – Module 9 – Energy requirements for lighting – Part 1: specification*

prEN 17037 *Daylight in building*

3. DEFINITIONS

illuminance (at a point Ep **on a surface Ea)** E

quotient of the luminous flux dΦ incident on an element of the surface containing the point, by the area dA of that element (unit: lm/m²) [EN 12665]

NOTE 1 The illuminance E is equivalent to the ratio of the luminous flux incident on an element of the surface to the area of that element .

NOTE 2 The illuminance E is expressed in lux (lx).

brightness
attribute of a visual perception according to which an area appears to emit, or reflect more or less light [EN 12665:2016]

rooflight
daylight transmitting assembly mounted over an opening in the ceiling of a room, which in most cases is also the roof of the building

NOTE There are many different types of rooflights, e.g. individual rooflights, dome lights, ridge roof or curved continuous rooflights, and shed lights, and the glazing's may have various angles of inclination.

light surface
area of the horizontal projection of the clear opening of the translucent part of all rooflights , in m^2

daylight autonomy (DA)
percentage of the time-in-use that a certain user-defined lux threshold is reached through the use of just daylight
In other words: percentage of annual work hours during which all or part of a building's lighting needs can be met through daylighting alone. Predicts the percentage of daylight hours where the illuminance meets or exceeds the desired task illuminance level

NOTE: DA is usually given as an annual value but seasonal, monthly and daily presentations can be made. The calculation procedure of DA is to determine the hourly illuminance level in a point in the room for the entire year. Credit is given if the illuminance level of an hour is above a certain lux threshold and belongs to a time-in-use period of the year.

spatial daylight autonomy (sDA)
percentage of floor area that receives at least 300 lux for at least 50% of the annual occupied hours
In other words: how much of a space receives a certain predefined amount of daylight for a certain predefined period of time
daylight factor D
ratio of the illuminance, E_p, at a point on a given plane due to light received directly or indirectly from a sky of known or assumed luminance distribution, to the illuminance, E_a, on a horizontal plane due to an unobstructed hemisphere of the sky, disregarding the direct components of both illuminances

$$D = \frac{E_p}{E_a} \cdot 100\ \%$$

NOTE: This factor allows for the effects of glazing, dirt accumulation and window frames, transoms, etc. For the purposes of this standard, a CIE standard overcast sky [1] is assumed, in which case the daylight factor is constant for all points in a room.

period of use t_{use}
time during which a given illuminance produced by daylight only is attained or exceeded at a workplace or in a given area of an interior space

NOTE: The period of use can be determined for a specific day, month, or season, or for the entire year. Another term for this is daylight autonomy.

relative period of use $t_{use,rel}$
ratio of the period of use to the respective working time

NOTE: The relative period of use $t_{use,rel}$ is expressed as a percentage [%].

Calculating DA and cDA

DA or cDA is calculated using hourly weather data, and is usually calculated for a point in the room or as contour/isolines illustrating the DA distribution throughout the room. DA and cDA is given as a percentage value but lux data for a point in the room can also be plotted to provide not only information on how much electrical lighting is needed but also when it is needed.

Uniformity U_0

The ratio of the minimum illuminance to the average illuminance ($U_0 = \bar{E}_{min}/\bar{E}$) [EN 12665]

NOTE: Equivalent uniformity $g_1 = D_{min}/D$ and uniformity $g_2 = D_{min}/D_{max}$ is used

5. RECOMMENDATIONS FOR THE LEVEL OF DAYLIGHT IN BUILDINGS

5.1 Objective

The objective is to achieve the recommended level of lighting and the uniformity by daylight only, during the maximum occupation time.

As a matter of course, artificial light can be added if the required level of lighting is not achieved.

The variable external conditions significantly influence the internal illuminance, produced by the natural lighting system.

The influencing factors are:

- geographical location (latitude),
- seasonal conditions,
- time of the day,
- weather conditions (cloudy, overcast sky, bright sun),
- environmental conditions (pollution).

As a consequence, specification of the daylight system and area requires a good balance between all the above mentioned factors and the needs and the comfort of the users

5.2 Geographical location (latitude) of selected European cities

	Town	Country	Latitude	Town	Country	Latitude	Town	Country	Latitude	Town	Country	Latitude
>60°-70° Extreme Northern Europe	Reykjavik	IS	64,1									
>55°-60° Northern Europe	Helsinki	FI	60,1									
	Stockholm	SE	59,3	Oslo	NO	59,9	Tallinn	EE	59,4			
	Moscou	RU	55,8	Kobenhavn	DK	55,7	Riga	LV	57			
>50°-55° Northern Middle Europe	Hamburg	DE	53,2	Dublin	IE	53	Vilnius	LT	54,7			
	Warszawa	PL	52,3	Berlin	DE	52,5	Amsterdam	NL	52,4			
	London	GB	51,5	Kassel	DE	51,3						
	Brussel	BE	50,8	Praha	CZ	50,1	Luxembourg	LU	49,6			
>45°-50° Middle Europe	Paris	FR	48,8									
	Strasbourg	FR	48,6									
	Vienna	AT	48,2	Bratislava	SK	48,2						
	Rennes	FR	48,1	Munich	DE	48,1						
	Nantes	FR	47,2	Bern	CH	47	Budapest	HU	47,5			
	Lyon	FR	45,8	Milan	IT	45,5	Ljubljana	SI	46	Zagreb	HR	45,8
>40°-45° Southern Middle Europe	Valence	FR	44,9	Bucuresti	RO	44,4	Beograd	RS	44,4			
	Toulouse	FR	43,6									
	Marseille	FR	43,3	Sofia	BU	42,7	Sarajevo	BA	43,3			
	Roma	IT	41,9	Barcelona	ES	41,4	Tirana	AL	41,9			
>35°-40° Southern Europe	Madrid	ES	40,4	Valencia	ES	39,4	Ankara	TR	40,4	Lisboa	PT	38,7
	Alger	DZ	36,8	Palermo	IT	38,1	Athens	GR	38	La Valette	MT	36,8

Table 1: Geographic locations of selected European cities grouped by a latitude bandwidth of 5°

5.3 Target value for daylight factor D

5.3.1 General explanation

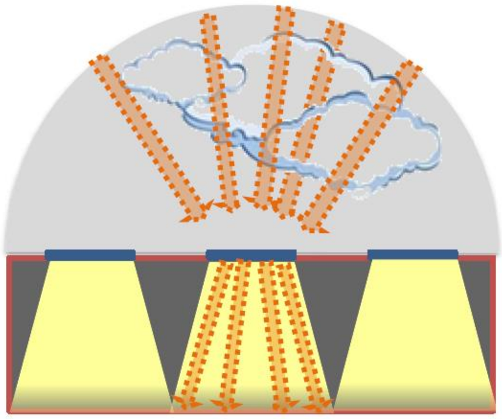
The target value for daylight factor is calculated using a meteo database.

This guideline uses data extracted from meteo bases from SATELIGHT (average of 5 years over the period 1996-2000)

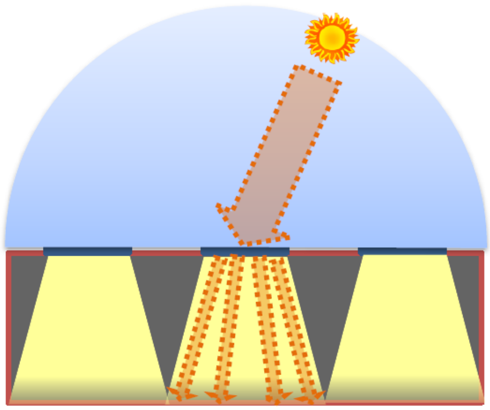
NOTE: For more information about SATELIGHT see Annex 2.

It is possible to use either diffuse illuminance value or global illuminance value. With diffuse, only the illuminance from the sky itself is taken into account. And with global illuminance a sum between sky illuminance and direct sun light illuminance is calculated.

With a diffuse transparent part it's possible to use the global illuminance because even the direct sun light is diffused by the translucent part.

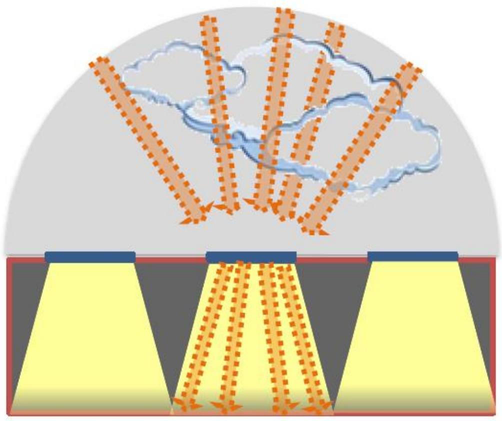


Overcast sky with diffuse glazing

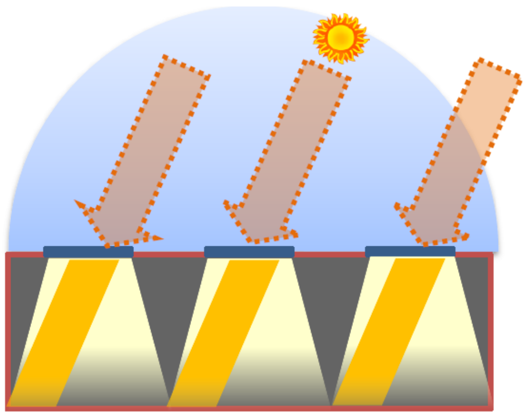


Direct sun light with diffuse glazing

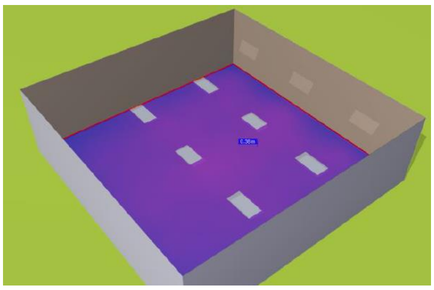
With transparent glazing it's possible only to use diffuse illuminance because direct sun light creates little area on the floor with a very high level of illuminance but totally non usable to calculate an average for the room's area. It create only some uncomfortable situation



Overcast sky with transparent glazing



Direct sun light with transparent glazing



5.3.2 For diffuse glazing- global external illuminance

For rooflights with diffuse glazing this guideline uses the global external illuminance for the determination of the recommended daylight factor.

The minimum daylight factor value shown below in Table 2 can produce illumination of 300 lux for 50% of the hours (between 6 h and 22 h). The recommended daylight factor without shading value can produce illumination of 500 lux for 50% of these hours without shading installed on the rooflights. The recommended daylight factor with shading value can produce illumination of 500 lux for 50% of these hours with shading installed on the rooflights

NOTE: When using the value of the level of illuminance for a certain city (in Table 2) keep in mind that the local climate may be different in spite of equivalent latitude.

	minimum daylight factor %	recommended daylight factor without shading %	recommended daylight factor with shading %
>60°-70° extreme northern Europe	4,0%	5,7%	6,7%
>55°-60° northern Europe	3,4%	4,8%	5,6%
>50°-55° northern middle Europe	3,1%	4,1%	5,2%
>45°-50° middle Europe	2,8%	3,7%	4,6%
>40°-45° southern middle Europe	2,0%	2,6%	3,3%
35°-40° southern Europe	1,4%	1,9%	2,3%

Table 2: Recommendations for daylight factors - minimum and recommended - for different European zones to achieve a certain daylight autonomy by rooflights with diffuse glazing.

	Town	Country	Latitude	level of global illuminance for 50 % of the time during a year between 6h and 22h	minimum > 300 Lux 50 % time	recommended > 400 Lux without shading 50 % time	recommended > 500 Lux with shading 50 % time
				Lux	D [%]	D [%]	D [%]
>60°-70° extreme northern Europe	**Reykjavik**	**IS**	**64,1**	**7.500**	**4,0%**	**5,7%**	**6,7%**
>55°-60° northern Europe	**Stockholm**	**SE**	**59,3**	**8.938**	**3,4%**	**4,8%**	**5,6%**
	Moscou	RU	55,8	10.468	2,9%	3,9%	4,8%
>50°-55° northern middle Europe	**Hamburg**	**DE**	**53,2**	**9.648**	**3,1%**	**4,1%**	**5,2%**
	Warszawa	PL	52,3	9.977	3,0%	4,0%	5,0%
	London	GB	51,5	10.448	2,9%	3,9%	4,8%
	Brussels	BE	50,8	10.421	2,9%	3,9%	4,8%
>45°-50° middle Europe	**Strasbourg**	**FR**	**48,6**	**10.797**	**2,8%**	**3,7%**	**4,6%**
	Paris	FR	48,8	12.215	2,5%	3,2%	4,1%
	Vienna	AT	48,2	11.298	2,7%	3,5%	4,4%
	Rennes	FR	48,1	12.947	2,3%	3,1%	3,9%
	Nantes	FR	47,2	13.681	2,2%	2,9%	3,7%
	Lyon	FR	45,8	13.214	2,3%	3,0%	3,8%
>40°-45° southern middle Europe	**Toulouse**	**FR**	**43,6**	**15.287**	**2,0%**	**2,6%**	**3,3%**
	Valence	FR	44,9	14.694	2,0%	2,7%	3,4%
	Marseille	FR	43,3	19.685	1,5%	2,1%	2,5%
	Roma	IT	41,9	19.332	1,6%	2,0%	2,6%
35°-40° southern Europe	**Madrid**	**ES**	**40,4**	**21.640**	**1,4%**	**1,9%**	**2,3%**
	Alger	DZ	36,8	23.247	1,3%	1,8%	2,2%

Table 3: Recommendations for daylight factors - minimum and recommended - for selected European cities in zones to achieve certain daylight autonomy by rooflights with diffuse glazing

NOTE: Members of EUROLUX are allowed to add some more cities of their country with associated values in an individual annex using the same procedure.

5.3.3 For clear glazing - diffuse external illuminance

For rooflights with clear glazing, this guideline uses the diffuse external illuminance for the determination of the recommended daylight factor.

This guideline uses data extracted from meteo bases from SATELIGHT (average of 5 years over the period 1996-2000)

NOTE: For more information about SATELIGHT see Annex 2

The minimum daylight factor will produce illumination of 300 lux for 50% of the hours (between 6 h and 22 h). The recommended daylight factor without shading value can produce illumination of 500 lux for 50% of these hours without shading installed on the rooflights. The recommended daylight factor with shading value can produce illumination of 500 lux for 50% of these hours with shading installed on the rooflights.

You must have shading during time of direct illuminance.

	minimum daylight factor %	recommended daylight factor without shading %	recommended daylight factor with shading %
>60°-70° extreme northern Europe	5,0%	6,0%	8,3%
>55°-60° northern Europe	4,2%	5,6%	6,9%
>50°-55° northern middle Europe	3,6%	4,9%	6,0%
>45°-50° middle Europe	3,3%	4,3%	5,4%
>40°-45° southern middle Europe	2,8%	3,8%	4,7%
35°-40° southern Europe	2,7%	3,6%	4,5%

Table 4: Recommendations for daylight factors - minimum and recommended - for different European zones to achieve certain daylight autonomy by clear transparent rooflights using variable shadings

	Town	Country	Latitude	level of global illuminance for 50 % of the time during a year between 6 h and 22h	minimum > 300 Lux 50 % time	recommended > 400 Lux without shading 50 % time	recommended > 500 Lux with shading 50 % time
				Lux	D [%]	D [%]	D [%]
>60°-70° extreme northern Europe	**Reykjavik**	**IS**	**64,1**	**7.500**	**5,0%**	**6,0%**	**8,3%**
>55°-60° northern Europe	**Stockholm**	**SE**	**59,3**	**8.938**	**4,2%**	**5,6%**	**6,9%**
	Moscou	RU	55,8	10.468	3,6%	4,9%	6,1%
>50°-55° northern middle Europe	**Hamburg**	**DE**	**53,2**	**9.648**	**3,6%**	**4,9%**	**6,0%**
	Warszawa	PL	52,3	9.977	3,5%	4,8%	5,9%
	London	GB	51,5	10.448	3,4%	4,5%	5,6%
	Brussels	BE	50,8	10.421	3,4%	4,5%	5,6%
>45°-50° middle Europe	**Strasbourg**	**FR**	**48,6**	**10.797**	**3,3%**	**4,3%**	**5,4%**
	Paris	FR	48,8	12.215	3,1%	4,1%	5,2%
	Vienna	AT	48,2	11.298	3,2%	4,3%	5,3%
	Rennes	FR	48,1	12.947	3,0%	4,0%	4,9%
	Nantes	FR	47,2	13.681	2,9%	3,9%	4,8%
	Lyon	FR	45,8	13.214	3,0%	4,0%	5,0%
>40°-45° southern middle Europe	**Toulouse**	**FR**	**43,6**	**15.287**	**2,8%**	**3,8%**	**4,7%**
	Valence	FR	44,9	14.694	2,9%	3,9%	4,9%
	Marseille	FR	43,3	19.685	2,8%	3,8%	4,7%
	Roma	IT	41,9	19.332	2,7%	3,6%	4,5%
35°-40° southern Europe	**Madrid**	**ES**	**40,4**	**21.640**	**2,7%**	**3,6%**	**4,5%**
	Alger	DZ	36,8	23.247	2,5%	3,4%	4,2%

Table 5: Recommendations for daylight factors - minimum and recommended - for selected European cities in zones to achieve certain daylight autonomy by clear transparent rooflights using variable shadings

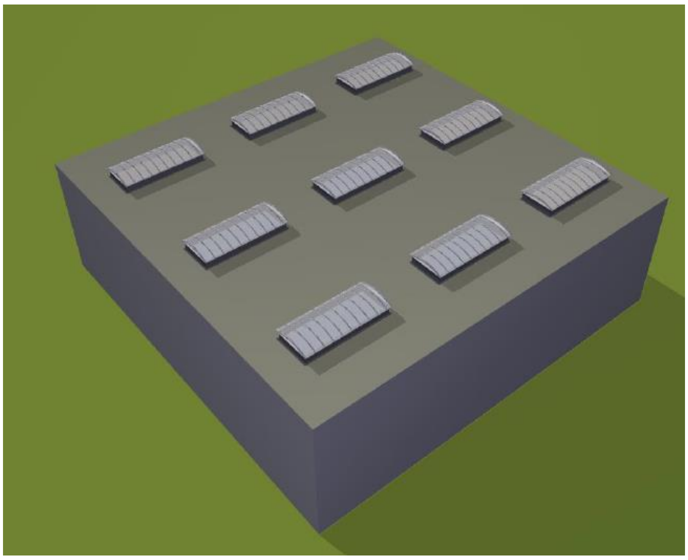
Note: Members of EUROLUX are allowed to add some more cities of their country with associated values in an individual annex using the same procedure.

6. Simplified approach for calculation of solution of rooflight for a building

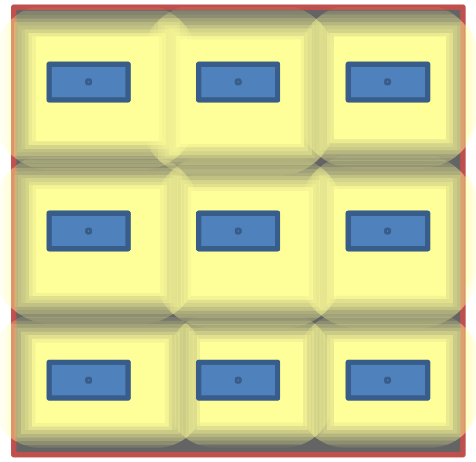
6.1 Calculation of numbers of rooflights

It is recommended to space individual rooflights at 1.0 to 1.5 times the ceiling height (center-to-center distance in both directions).

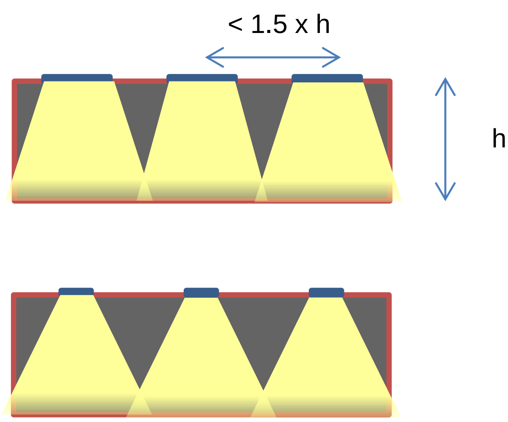
Correct lay out 3d view



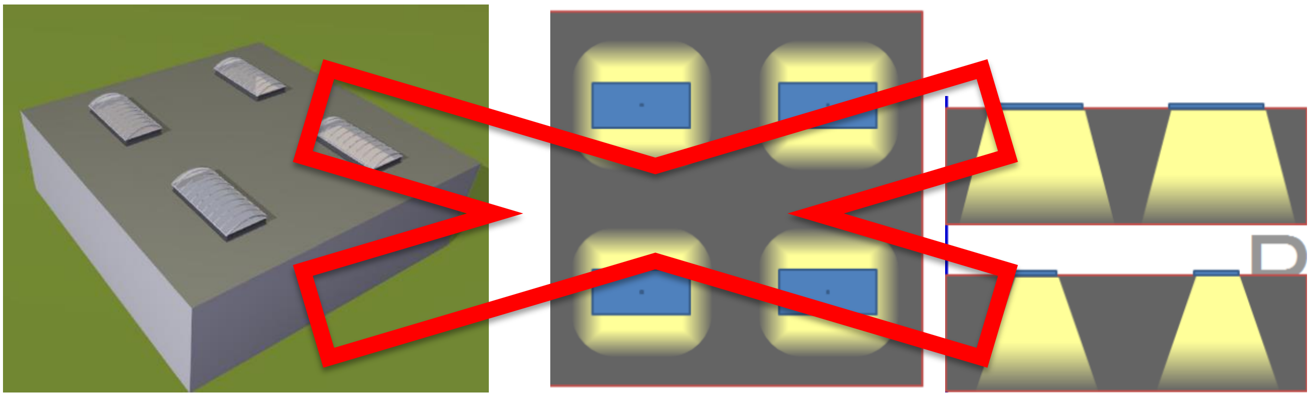
Correct lay out top view



correct lay out cross view



Not enough light points /incorrect layout



h height

Figure 4: Qualitative spreading of daylight factor in a room with rooflights

height of ceiling	maximum floor area lighted by rooflight
m	m²
4	30
5	40
6	50
7	60
8	70
9	80
10	90
11	100
12	100

Table 6 : Relation between height of ceiling and roof openings for rooflights based on common practice

$$\text{Minimum number of rooflights} = \frac{\text{building area}}{\text{maximum floor area lighted by rooflights}}$$

NOTE: Must be rounded to the upper value.

For example: A building of 1.000 m² with a height of 8 m needs minimum 15 rooflights (1000 / 70 = 14.3 rounded to 15) .
It is allowed to interpolate between lines from table 6. It is recommended to round the calculated figures up in whole numbers.

6.2 Different Lighting strategies with rooflights

The main target is to achieve a minimum illuminance level within a space. This can be done by using different lighting strategies.

If the designer wishes to have more illuminated spot areas, individual rooflights are the better choice.

If the designer wishes to have more illuminated strip areas, continuous rooflights are the better choice.

It could also be possible to reach an equivalent result with a combination of both rooflight types.

Conclusion:

The designer must give a proposal for a solution that fulfils the requirements with the most economic solution for the customer and user.

6.3 Conservative and simplified method of calculation of light surface

In non-residential buildings for heights from 4 m to 10 m with rooflight dimensions starting with 1.2 m x 1.2 m (minimum of light area) and upstand height of 500 mm maximum, the percentage of daylit surface should be calculated according to the following formula :

$$\textbf{Percentage of light surface of the roof area} = \frac{K_L}{\tau_{D65}} \times D$$

With

D	daylight factor
K_L	matching coefficient
τ_{D65}	Light transmission for standard light source D65 (in %)

The matching coefficient K_L is determined as:

$\boxed{K_L = 2,3}$

to achieve the best compromise between existing calculation methods . When using this equation and the recommended daylight factor you have to consider shading devices for certain times of the year.

Example of application: (with a diffuse glazing)

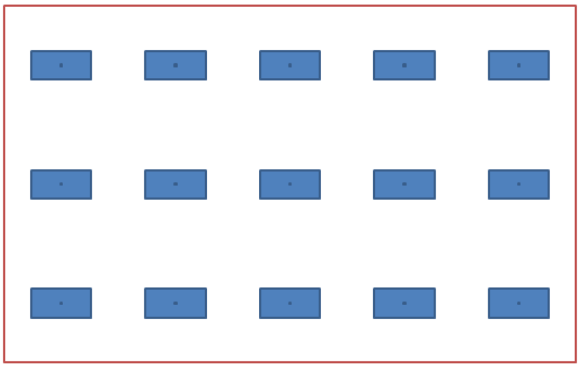
Middle Europe : Strasbourg: minimum daylight factor = 2.8 % (Table 3), τ_{D65} = 52%
Geometrical light area ratio= 2.3 x 2.8 / 0.52 = 12.4 %
Calculation of geometrical area of rooflight for a building height of 8 m of 1.000 m² = 1000 x 12.4% = 124 m²

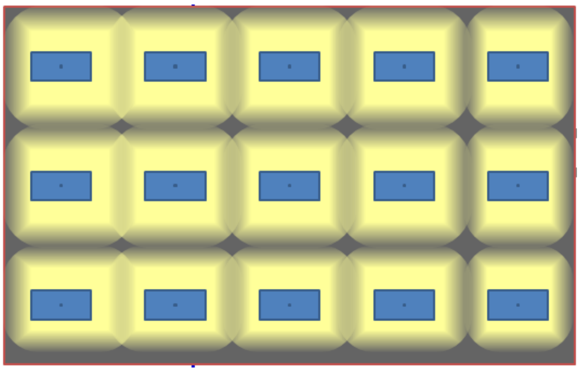
Minimum amount of rooflight :
Table 6 => building's height = 8 m => 70m² fby rooflight

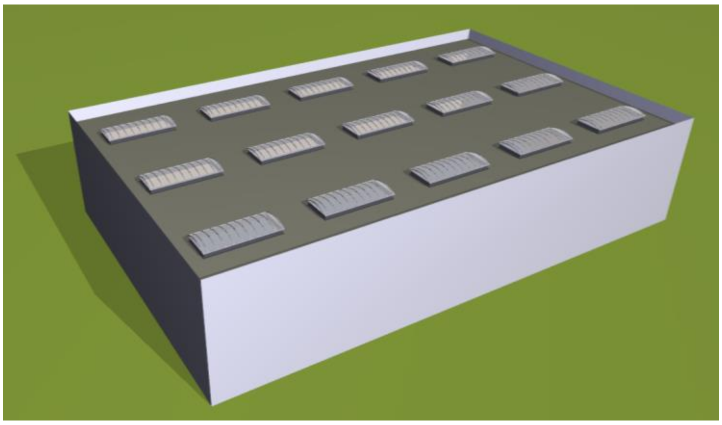
So the minimum quantity of rooflight is 1000 m² / 70 m²= 14.3 rounded up to 15.

1) With 15 rooflights (individual or continuous)
Area of a rooflight 124/15 = 8.27 m²
Choice of dimensions of rooflights 2 x 4.13 m

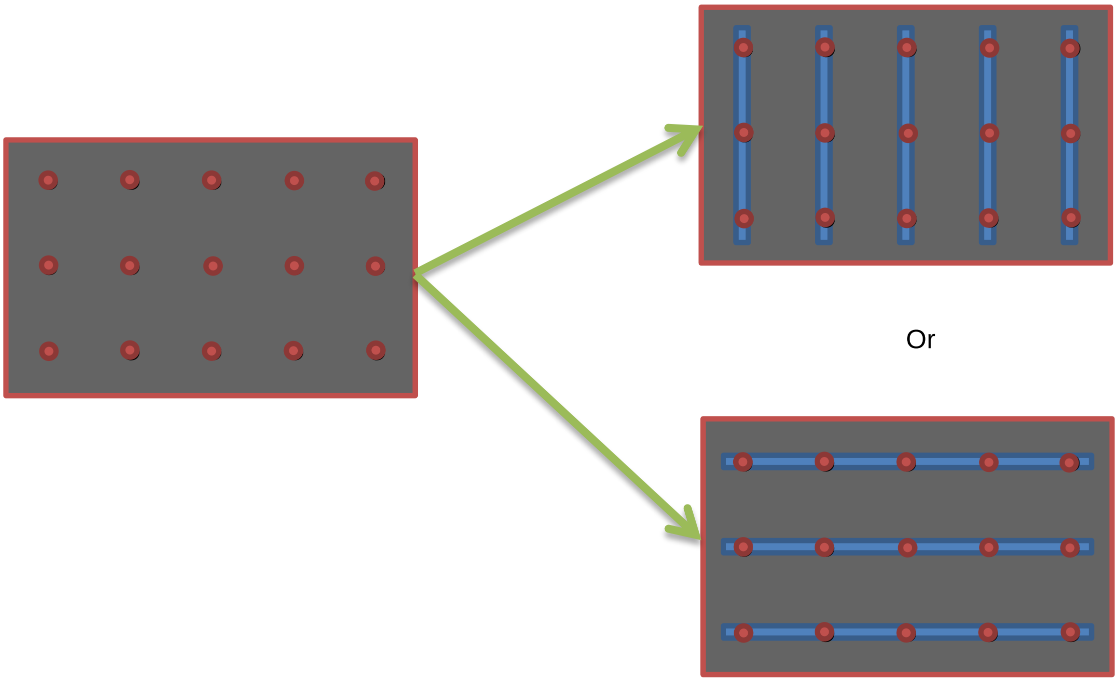
<u>Illustration showing the solution:</u>



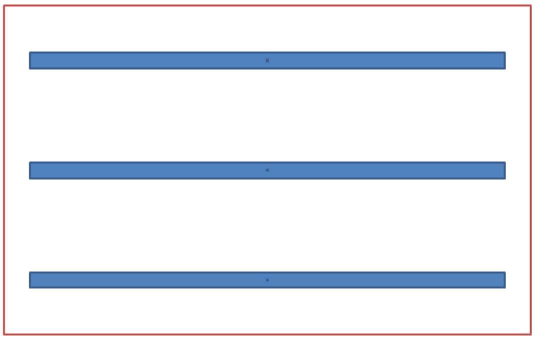


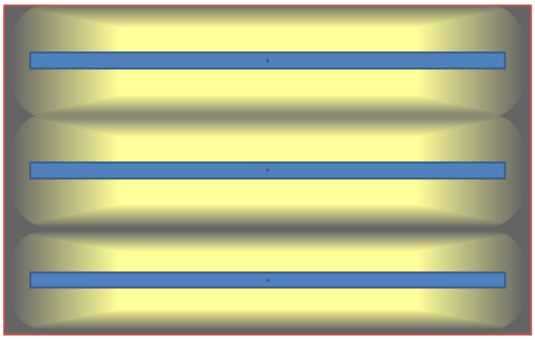


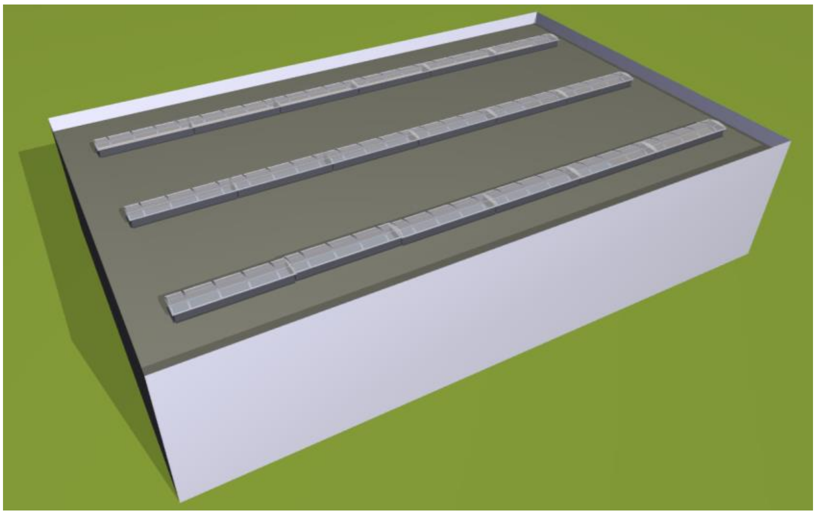
2) With continuous rooflight between walls
In order to find a good arrangement for continuous rooflights it's possible to use a drawing with one point for each individual rooflight. The solution is validated if there is one continuous rooflight on each point of the grid.



3 continuous rooflights, length = 40 –(2 x 2) =36 m
Width for rooflights = 124 / (36 x 3) = 1.2 m







This conservative and simplified method of calculation of light surface provides a good approach to a solution for daylighting in buildings.

The Results of this method calculation should be compared with other detailed and computer methods. If you find greater than ± 30 % difference with this conservative method, you have to check your calculation!

7. DAYLIGHT AUTONOMY

7.1 Example of daylight autonomy

You can see in examples N°1 and N°2 there are different numbers of hours during a month where the illuminance meets or exceeds the desired task illuminance level of 300 Lux and 1.000 Lux in the building.

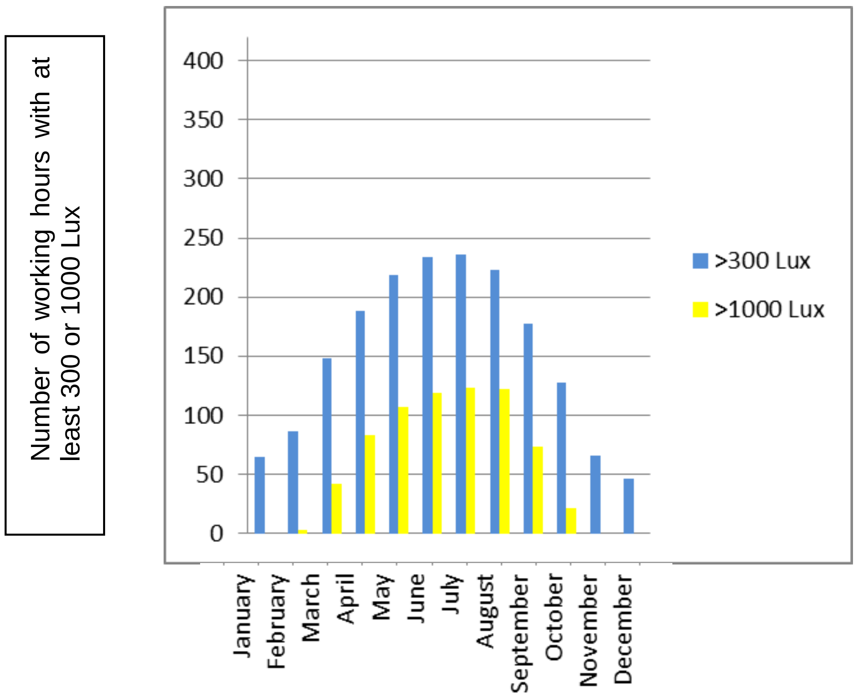
With the building in example N°1 the natural lighting system of rooflights give a daylight factor D = 2.5 %.
In June we have more than 300 hours at the desired task illuminance level of 300 Lux and more than 180 hours at the desired task illuminance level of 1.000 Lux in the building.
In February we have more than 130 hours at the desired task illuminance level of 300 Lux in the building.
So you can reduce artificial lighting during all these hours with daylighting

With the building of example N°2 the natural lighting system of rooflights give a daylight factor D = 0.7 %.
In June we have more than 160 hours at the desired task illuminance level of 300 Lux and no hours at the desired task illuminance level of 1.000 Lux in the building.
In February we have more than 10 hours at the desired task illuminance level of 300 Lux in the building.
So in this case the benefit of reduced artificial lighting is very small.

<u>Example N°1</u>

building area : 5000 m²
height of building: 8 m
location: Paris
daylight factor: 2.5 % - (minimum daylight factor from Table 3)
geometric light area 11 %
rooflight with a diffuse glazing:

light transmission: τ_{D65}: 52%

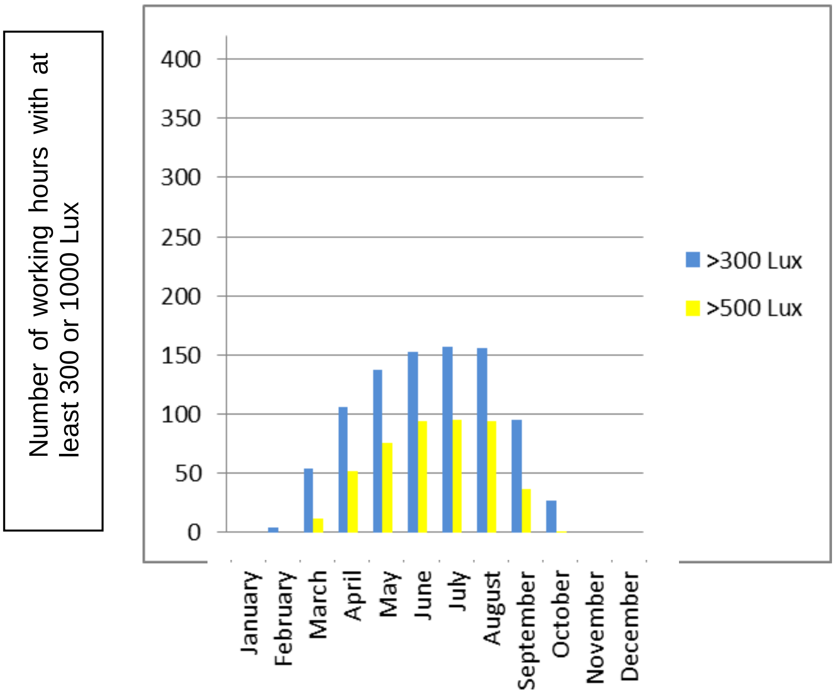


Note : this monthly data came from the satellight database

Example N°2

building area : 5000 m²
height of building: 8 m
location: Paris
daylight factor: 0.7 %
geometric light area 3 %
rooflight with a diffuse glazing:

light transmission: τ_{D65}: 52%



In June, there is :

for D = 2.5 %	for D = 0.7 %
11 % geometric light area	3 % geometric light area
more than 300 h at 300 Lux	160 h at 300 Lux
more than 180 h at 1.000 Lux	0 h at 1.000 Lux

In February there is:

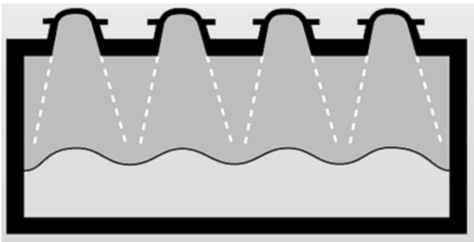
for D = 2.5 %	for D = 0.7 %
11 % geometric light area	3 % geometric light area
More than 130 h at 300 Lux	10 h at 300 Lux

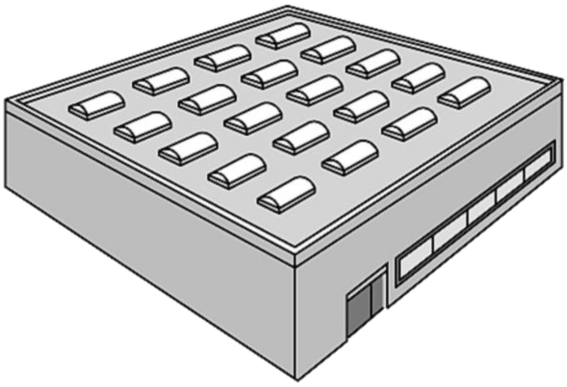
8. Recommendations for installations

General rules of thumb for layout, design, placing and assembly of rooflights

Rooflights with smaller sizes in a sufficient number uniformly distributed on the roof area provide a more uniform illumination of the interior space (rooms or halls) than bigger ones.

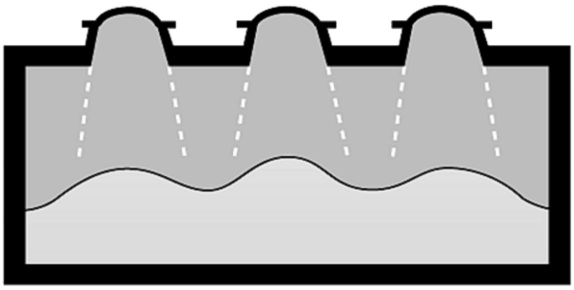
Daylighting with individual rooflights

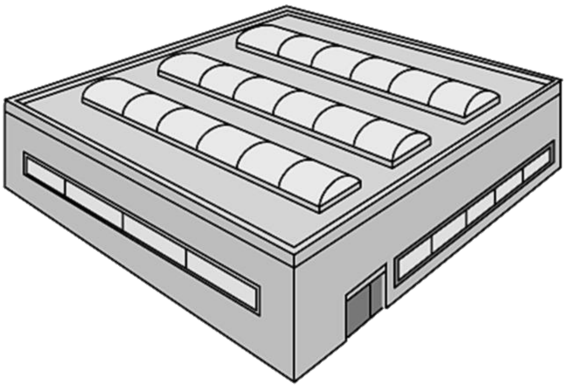




Interiors with low ceilings should have smaller openings located closer to each other, Interiors with high ceilings allow larger openings with bigger distances between each opening.

Daylight with continuous rooflights





It is recommended to install a balanced mixture of different rooflight types – continuous rooflights for example for orientation above main aisles, individual rooflights for a more uniform distribution of illumination.

It is recommended to select only one rooflight type for a certain roof installation with reference to the dimensions of the rooflight (for individual rooflight) or to select continuous rooflights basically with the same width. This guarantees no confusion in placing and assembling at site.

It is recommended for continuous rooflights to make the width of the rooflight no larger than half of the height from floor to the ceiling.

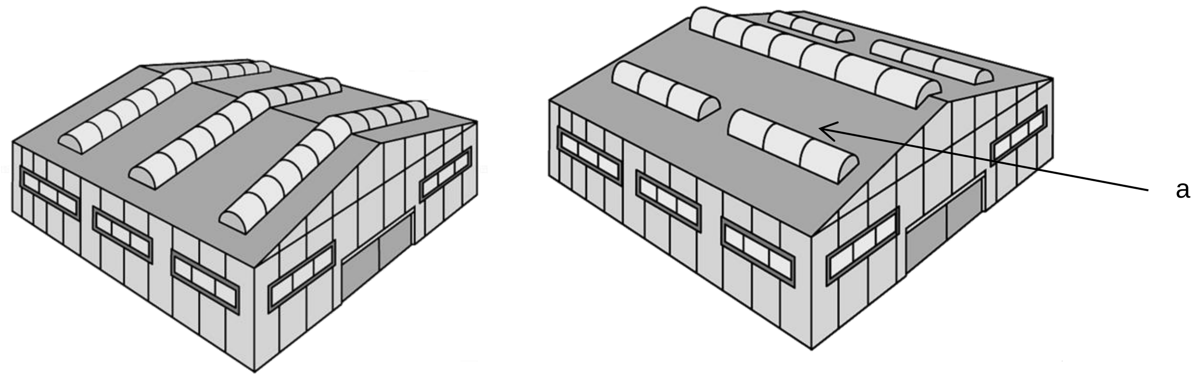
It is recommended to space individual rooflights at 1.0 to 1.5 times the ceiling height (center-to-center/center distance in both directions)

It is recommended for continuous rooflights to choose the distance “e” from rooflight to rooflight equal or bigger than two times the rooflight width b ($e \geq 2$ b).

It is recommended to have a minimum gap of 1 m from one individual rooflight to the next one. Doing this roofers have enough space for reliable assembly, a secure fastening and a watertight sealing. Furthermore there is sufficient access for maintenance.

For continuous rooflights it is recommended to start the rooflight construction on the second main truss and to end one before the last one, so to leave blank the first and last truss field. This simplifies a lot the junction construction of the surrounding upstand to the roof.

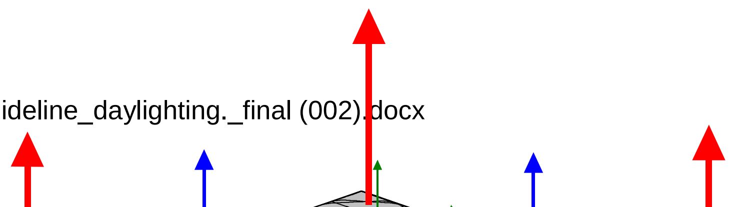
Drainage
Continuous rooflights can be oriented from ridge to eaves, if ridge roofs have a slight slope.

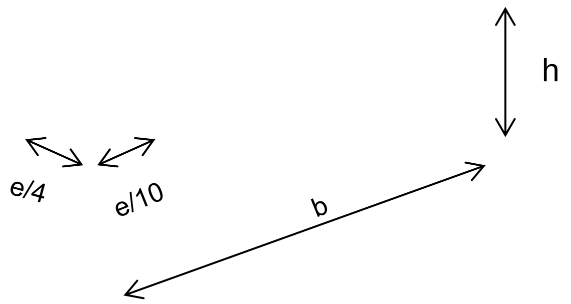


It is recommended to place a continuous rooflight at the ridge of a ridge roof. Furthermore for membrane roof coverings it is possible to arrange continuous rooflights in a ridge roof parallel to the ridge, if the length of the continuous rooflight does not exceeds more than 10 m and the height of the upstand is sufficient (height of the upstand above roof surface at least 25 cm). This doesn’t apply to corrugated sheets or metal profiled sheets.

NOTE: In such cases it is recommended to use a drainage wedge made of insulation material within the roof construction (zone a).

Wind loads (risks at the edges of roofs)
Due to severe wind suction peaks at edges and corners of flat roofs or low sloped roofs it is recommended not to install rooflights within 2,0 m of the edge or otherwise it will be necessary to determine and use additional fastenings for higher wind loads.





e = b or 2h and
minimum 2 m

NOTE:
Buildings of a total height above 20 m and located in exposed areas can have also wind suction peaks within the mid field of the roof.
For detail information see Eurocodes EN1991-1-3.

It is recommended to use a glazing material which provide a good optical refraction that ensures a satisfactory diffuse illumination of the interior spaces below the rooflights. The use of clear glazing is generally not recommended for individual or continuous rooflights.

9. LITERATURE

Fischer, U., Der Transmissionsgrad für Fenster bei Beleuchtung durch den bedeckten Himmel, Lichttechnik 27 (1975), H. 12, S. 461

Fischer, U.: Oberlichter – Beleuchtung als Geschenk des Himmels, F. H. Kleffmann Verlag GmbH, Bochum 2003

Tonne, F, Besser bauen mit Besonnungs- und Tageslichtplanung,-1, Verlag Karl Hoffmann, Schorndorf, 1954

Longmore, J., The BRS Daylight Protractor, H.M.S.O., London, 1986

Schmidt, M., Eine Möglichkeit der Berechnung des Tageslichtquotienten bei ungleichmäßiger Verbauung vor senkrecht stehenden Fenstern, Licht 53 (2001), H. 1/2, S. 62-69

Krochmann, J. und Lindner, U., Tageslichtbeleuchtung für Fenster mit lichtstreuenden Gläsern, Lichttechnik 23 (1971), H. 3, S. 131

Tageslicht“, aus: Handbuch für Beleuchtung, 5. Auflage 1992, ecomed-Verlagsgesellschaft mbH, Landsberg am Lech

S. Aydinli, J. Krochmann, M. Seidl, Possibilities for Energy Saving for Electrical Light of Interiors in Consideration of the Visual Task; Proceedings of the European Conference on Architecture, 6-10. April 1987, Munich, Germany

Reinhart, C F, Daylight Availability and Manual Lighting Control in Office Buildings – Simulation Studies and Analysis of Measurements; Karlsruhe 2001

ANNEX 1

TABLE OF RECOMMENDATION OF ILLUMINANCE LEVELS/ EN 12464-1

$\bar{E}_m$ [lx] = average maintained illuminance in Lux

The average maintained illuminance on the reference surface shall not fall below the value given below. They are valid for normal visual conditions and take in account factors of visual comfort, well-being, visual tasks and ergonomics, functional safety, economy, practical experience.

Lighting requirements for interior areas, tasks and activities

This level of illuminance is necessary to have good conditions for the activity. It is possible to have this level by daylight a sufficient part of the time and electrical lighting the rest of the time

Traffic zones inside buildings

Type of area, task or activity	$\bar{E}_m$ [lx]
Ref. no. 5.1.1 Circulation areas and corridors	100

General areas inside buildings – Rest, sanitation and first aid rooms

Type of area, task or activity	$\bar{E}_m$ [lx]
Ref. no. 5.2.1 Canteens, pantries	200
Ref. no. 5.2.3 Rooms for physical exercise	300
Ref. no. 5.2.5 Sick bay	500

General areas inside buildings – Control rooms

Type of area, task or activity	$\bar{E}_m$ [lx]
Ref. no. 5.3.1 Plant rooms, switch gear rooms	200
Ref. no. 5.3.2 Telex, post room, switchboard	500

General areas inside buildings – Storage rack areas

Type of area, task or activity	$\bar{E}_m$ [lx]
Ref. no. 5.5.2 Gangways: manned	150
Ref. no. 5.5.4 Storage rack face	200

Industrial activities and crafts

Type of area, task or activity	$\bar{E}_m$ [lx]
Ref. no. 5.8.3. General machine work	300
Ref. no. 5.11.5 Assembly work Electrical and electronic industry- rough, e.g. large transformers	300
Ref. no. 5.18.9 Sheet metalwork: thickness < 5 mm	300
Ref. no. 5.19.2 Paper manufacture and processing, paper and corrugating machines, cardboard manufacture	300
Ref. no. 5.24.6 General vehicle services, repair and testing	300
Ref. no. 5.24.2 Body work and assembly vehicle	500
Ref. no. 5.10.5 Pharmaceutical production	500
Ref. no. 5.19.3 Standard bookbinding work, e.g. folding, sorting, gluing, cutting, embossing, sewing	500
Ref. no. 5.9.4 Grinding of optical glass, crystal, hand grinding and engraving	750
Ref. no. 5.9.6 Precision work e.g. decorative grinding, hand painting	1000
Ref. no. 5.11.6 Electronic workshops, testing, adjusting	1500

Offices

Type of area, task or activity		$\bar{E}_m$ [lx]
Ref. no. 5.26.6	Reception desk	300
Ref. no. 5.26.2	Writing, typing, reading, data processing	500
Ref. no. 5.26.3	Technical drawing	750

Retail premises

Type of area, task or activity		$\bar{E}_m$ lx
Ref. no. 5.27.1	Sales area	300
Ref. no. 5.27.2	Till area	500

Places of public assembly – Trade fairs, exhibition halls

Type of area, task or activity		$\bar{E}_m$ [lx]
Ref. no. 5.31.1	General lighting	300

Educational premises – Educational buildings

Type of area, task or activity		$\bar{E}_m$ [lx]
Ref. no. 5.36.1	Classrooms, tutorial rooms	300
Ref. no. 5.36.2	Classroom for evening classes and adults education	500
Ref. no. 5.36.8	Technical drawing rooms	750

Health care premises – Examination rooms (general)

Type of area, task or activity		$\bar{E}_m$ [lx]
Ref. no. 5.40.1	General lighting	500
Ref. no. 5.40.2	Examination and treatment	1 000

Health care premises – Operating areas

Type of area, task or activity		$\bar{E}_m$ [lx]
Ref. no. 5.46.1	Pre-op and recovery rooms	500
Ref. no. 5.46.2	Operating theatre	1 000

ANNEX 2 (INFORMATIVE)1

SATELIGHT

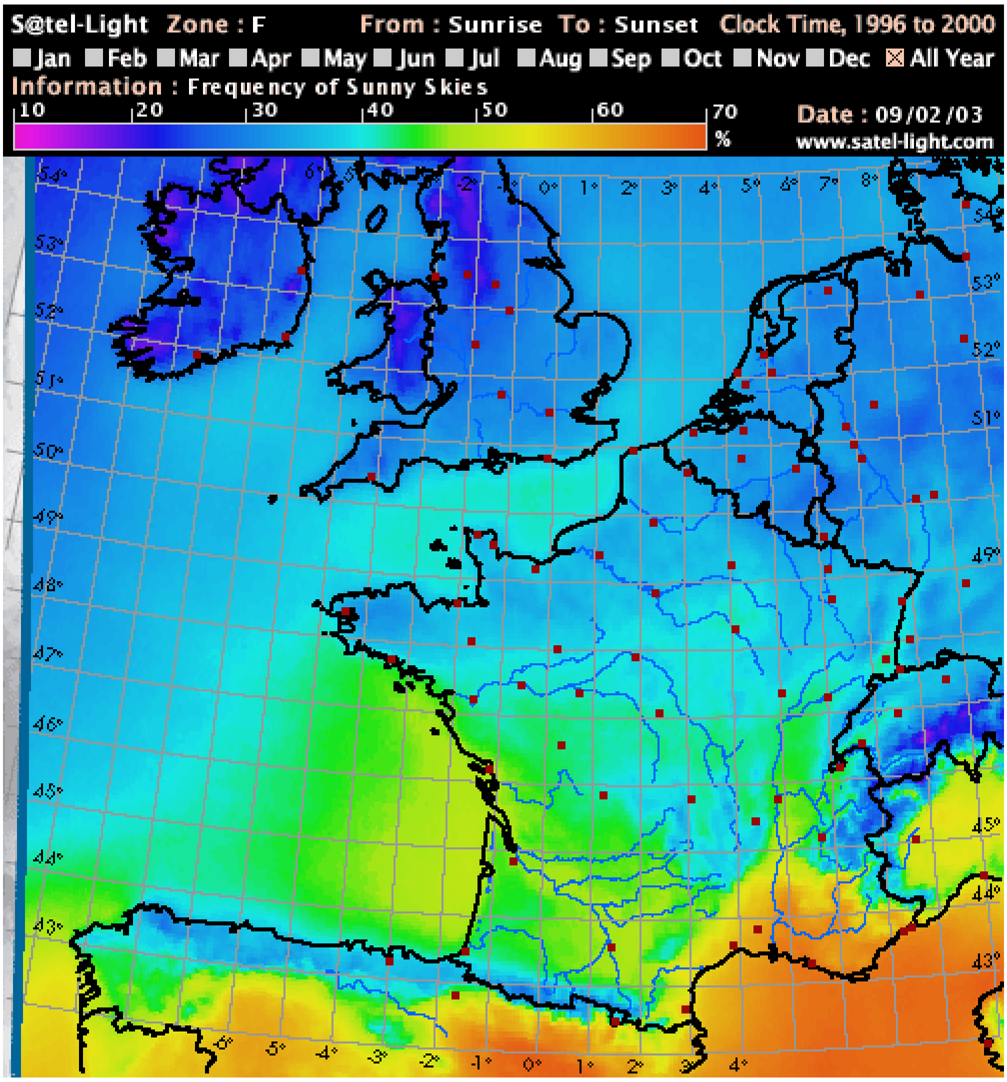
Developed by 10 European research groups and coordinated by a team of the Département Génie Civil et Bâtiment (DGCB-CNRS) at the Ecole Nationale des Travaux Publics de l'Etat (ENTPE), in Lyon, France, SATELLIGHT is a European research programme (Joule DGXII) aiming at making available on the Internet, a database of daylight and solar radiation for Western and Central Europe (from Lisbon to Moscow). The data is computed from images provided by the METEOSAT satellite, every half hour, and covers an area of about 10 km by 10 km. The data will be pre-processed and organized to be directly usable, by engineering firms working in energy and lighting, by industries developing lighting, shading or control systems, by urban planners and the entire agricultural sector

website www.satel-light.com/core.htm

Map of the Week

Copyright Satel-Light

The information presented in this map is based on Meteosat Satellite images obtained every half hour - See our advanced guide for more information.



ANNEX 3 (INFORMATIVE)

EXAMPLES OF SOLUTIONS FOR DAY LIGHTING BY ROOFLIGHTS

For example:

middle Europe Strasbourg :

D = 2.8 %

τ_{D65} = 52% ➔ % light surface = 12.4 %

τ_{D65} = 45% ➔ % light surface = 14.3 %

τ_{D65}= 30% ➔ % light surface = 21.5 %

D = 4.6 %

τ_{D65} = 52% ➔ % light surface = 20.3 %

τ_{D65} = 45% ➔ % light surface = 23.5 %

τ_{D65} = 30% ➔ % light surface= 35.3 %

northern Middle Europe Hamburg

D = 3.1 %

τ_{D65} = 52% ➔ % light surface= 13.7 %

τ_{D65} = 45% ➔ % light surface = 15.8 %

τ_{D65} = 30% ➔ % light surface = 23.8 %

D = 5.2 %

τ_{D65} = 52% ➔ % light surface= 23 %

τ_{D65} = 45% ➔ % light surface = 26.6 %

τ_{D65} = 30% ➔ % light surface= 39.9 %

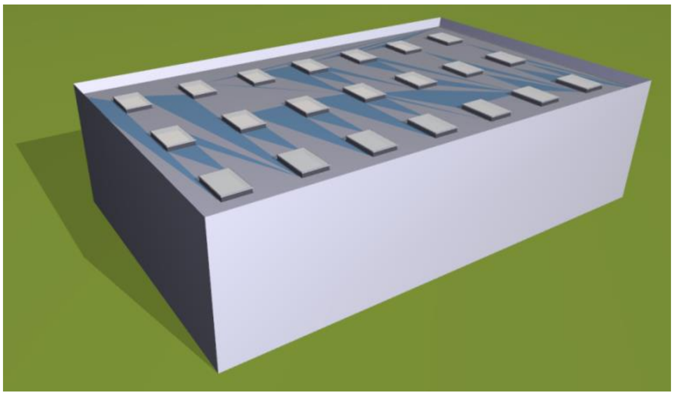
Examples of solutions for daylighting by rooflights
with light transmission τ_{D65}: 52%

building size: 25 m x 40 m
building area : 1000 m²
height of building: 8 m
reflectance factor of walls (7-5-2)
location: Paris

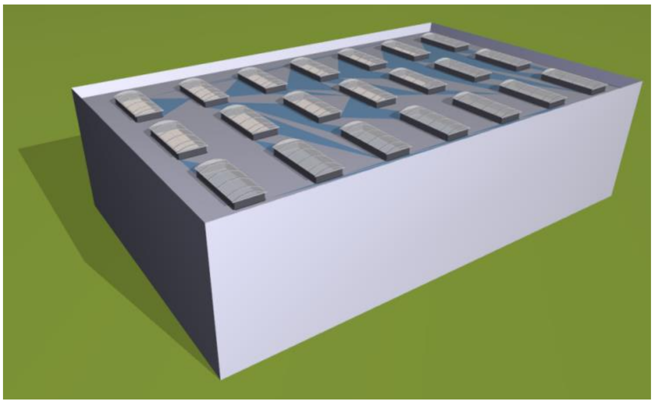
	minimum	recommended
daylight factor	2.8 %	4,60%
geometric light area	12,6 %	21 %

rooflight with light transmission τ_{D65}: 52%

daylight factor	2,80%
minimum number of rooflights to have a good uniformity for h = 8 m : 15	
simplified method	21 rooflights 2 m x 3 m (area of daylight) with τ_{D65} 52 %
	geometrical light area = 12,6 % of floor area



daylight factor	4,60%
minimum number of rooflights to have a good uniformity for h = 8 m : 15	
simplified method	21 rooflights 2 m x 5 m (area of daylight) with τ_{D65} 52 %
	geometrical light area = 21 % of floor area



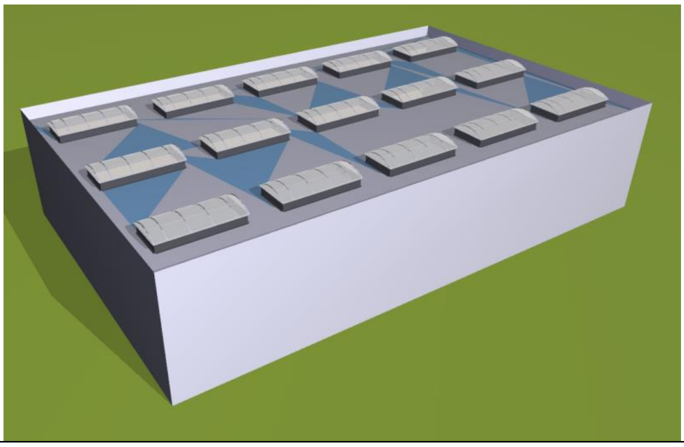
Examples of solutions for day lighting by rooflight
with light transmission τ_{D65}: 30%

building sizes: 25 m x 40 m
building area : 1000 m²
height of building: 8 m
reflectance factor of walls (7-5-2)
location: Paris

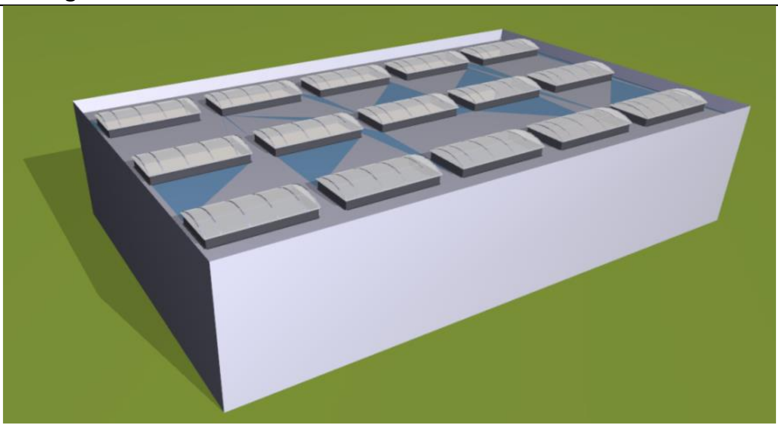
	Minimum	Recommended
daylight factor	2.8 %	4,60%
geometric light area	21.5 %	35.3 %

rooflight with light transmission τ_{D65}: 30%

daylight factor 2,80 %
minimum number of rooflights to have a good uniformity for h = 8 m : 15 Choice of 15 rooflights 2.5 m x 5.6 m (area of daylight) with τ_{D65} 30 %
○ geometrical light area = 21 % of floor area



daylight factor 4.6 %
minimum number of rooflights to have a good uniformity for h = 8 m : 15
○ Choice of 15 rooflights 3 m x 7.6 m (area of daylight) with τ_{D65} 30 %
○ geometrical light area = 34.2 % of floor area



ANNEX 4 (INFORMATIVE)
EXAMPLE OF CALCULATION OF ENERGY THROUGH ROOFLIGHT DURING A YEAR WITH DIFFERENT VALUES OF U_{RC} AND τ_{D65}:

Example of calculation of energy through rooflight during a year according to French CEE (ADEME):
building area : 5000 m²
height of building: 8 m
location: Paris
electric maintained illuminance level 1 000 lux
daylight factor: 2.5 % -
geometric light area 11 %

rooflight with light transmission τ_{D65}: 52% with U_{rc} 2 W/(m² °K)

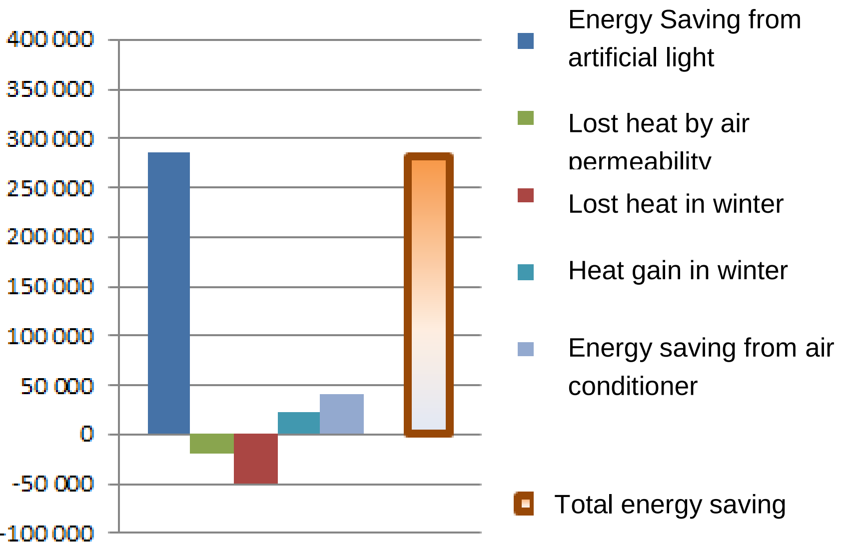
energy saving from artificial light : + 286 000 kWh / year

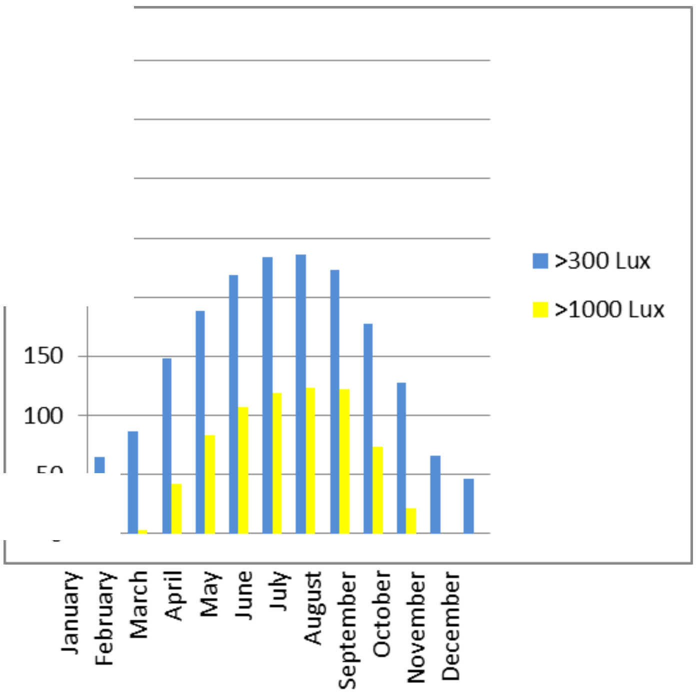
heat loss in winter : - 50 000 kWh / year

solar heat gain in winter : + 22 000 kWh / year

energy savings from air conditioner : + 41 000 kWh / year

total Energy savings : + 280 000 kWh / year





Example of calculation of energy passing through rooflights during a year:

building area : 5000 m²
height of building: 8 m
location: Paris
electric light inside 1 000 lux
daylight factor: 1.5 % -
geometric light area 11 %
rooflight with light transmission τ_{D65}: 31% with U_{rc} 1 W/(m² °K)

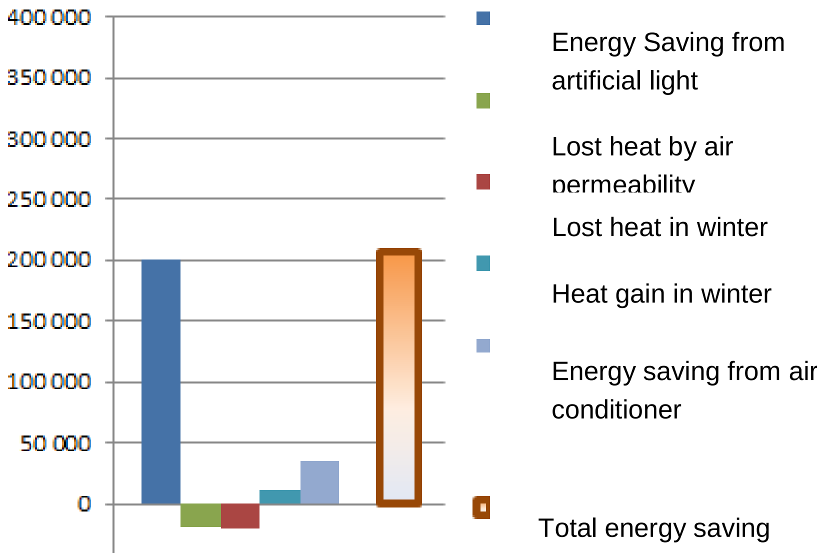
energy saving from artificial light : + 200 000 kWh / year

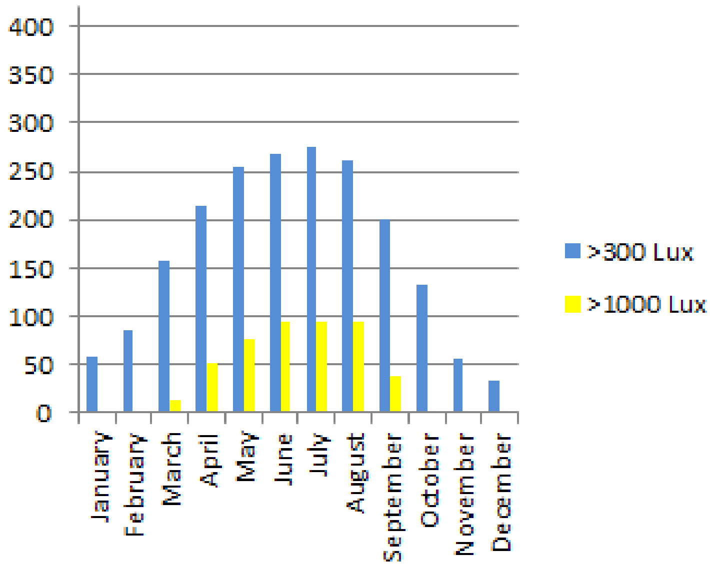
heat loss in winter : - 21 000 kWh / year

solar heat gain in winter : + 11 000 kWh / year

energy savings from air conditioner : + 34 000 kWh / year

total energy savings: + 200 000 kWh / year





Example of calculation of energy passing through rooflights during a year:

building area : 5000 m²
height of building: 8 m
location: Paris

electric light inside 1 000 lux
daylight factor: 2.5 % -
geometric light area 18 %
rooflight with light transmission τ_{D65}: 31% with U_{rc} 1 W/(m² °K)

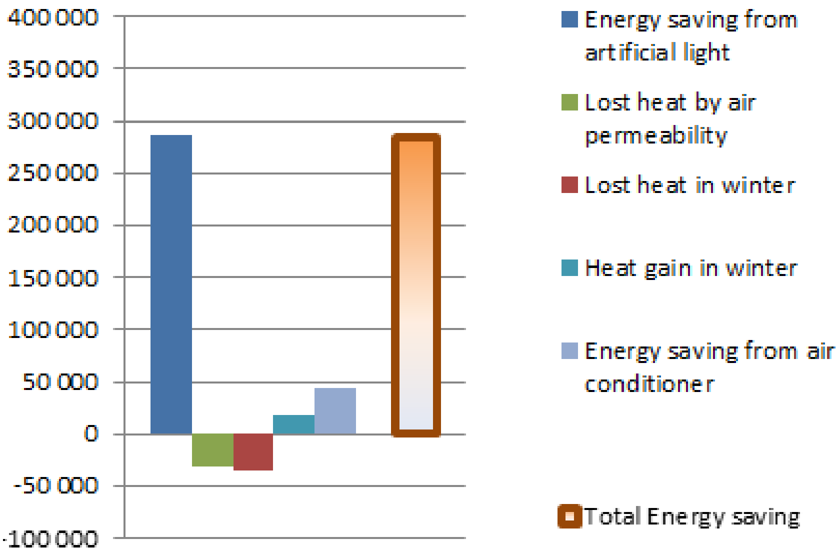
energy savings from artificial light : + 290 000 kWh / year

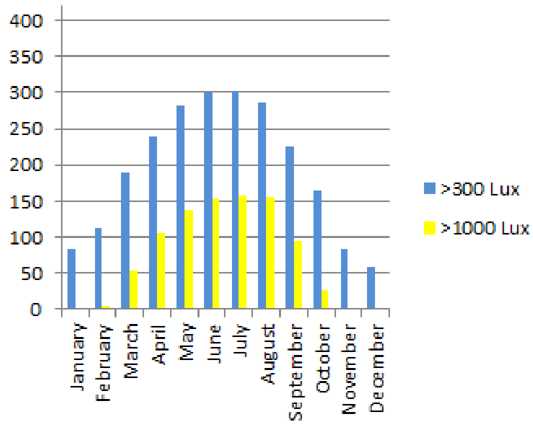
heat loss in winter : - 34 000 kWh / year

solar heat gain in winter : + 19 000 kWh / year

energy savings from air conditioner : + 44 000 kWh / year

total energy savings: + 280 000 kWh / year





ANNEX 5

OVERVIEW OF ADDITIONNAL CITIES CHOSEN BY EUROLUX MEMBERS

Table 3 to

Global illuminance

Other cities of countries from members of EUROLUX with associated values using the same procedure.

	Town	Country	Latitude	level of global illuminance for 50% of the time during a year between 6 h and 22h	daylight Factor: minimum > 300 Lux 50 % time	daylight Factor: recommended > 500 Lux 50 % time
				Lux	D [%]	D [%]
>60°-70° extreme northern Europe	Reykjavik	IS	64,1	7.500	4,0%	6,7%
>55°-60° northern Europe	Stockholm	SE	59,3	8.938	3,4%	5,6%
	???	???	???	???	???	???
>50°-55° northernmiddle Europe	Hamburg	DE	53,2	9.648	3,1%	5,2%
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
>45°-50° middle Europe	Strasbourg	FR	48,6	10.797	2,8%	4,6%
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
>40°-45° southern middle Europe	Toulouse	FR	43,6	15.287	2,0%	3,3%
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
35°-40° southern Europe	Madrid	ES	40,4	21.640	1,4%	2,3%
	???	???	???	???	???	???

Table 5 to

Diffuse illuminance						
Other cities of countries from members of EUROLUX with associated values using the same procedure.						
					Day light Factor	
	Town	Country	Latitude	level of diffuse illuminance for 50% of the time during a year between 6 h and 22h	minimum > 300 Lux 50 % time	recommended > 500 Lux 50 % time
				Lux	D [%]	D [%]
>60°-70° extreme northern Europe	Reykjavik	IS	64,1	6.000	5,0%	8,3%
>55°-60° northern Europe	Stockholm	SE	59,3	7.203	4,2%	6,9%
	???	???	???	???	???	???
>50°-55° northern middle Europe	Hambourg	DE	53,2	8.292	3,6%	6,0%
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
>45°-50° middle Europe	Strasbourg	FR	48,6	9.196	3,3%	5,4%
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
>40°-45° southern middle Europe	Toulouse	FR	43,6	10.643	2,8%	4,7%
	???	???	???	???	???	???
	???	???	???	???	???	???
	???	???	???	???	???	???
35°-40° southern Europe	Madrid	ES	40,4	11.150	2,7%	4,5%
	???	???	???	???	???	???

??? cities and associated values to be added later by EUROLUX members if available