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Light and lighting — Energy performance of lighting in buildings

Lumière et éclairage — Performance énergétique de l'éclairage des bâtiments

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

ISO collaborates closely with the International Commission on Illumination (CIE) on all matters of standardization for light and lighting.

This document was prepared by Technical Committee ISO/TC 274, *Light and lighting*. The document has been jointly prepared with CIE JTC 6, *Energy performance of lighting in buildings*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

It is of paramount importance that correct lighting is provided in buildings. The convention and procedures in this document assumes that the designed and installed lighting scheme conforms to good lighting practices. For new and refurbished installations in the non-residential building sector the design of the lighting system should conform to the requirements in the lighting applications standards ISO 8995-1/CIE S 008 for indoor workplaces and ISO 30061/CIE S 020 for emergency escape lighting. This document also assumes that the buildings can have access to daylight to provide all or some of the illumination required in the rooms or zones and that in addition there will be an adequate amount of electric lighting installed to provide the required illumination in the absence of daylight.

This document defines the methods for estimating or measuring the amount of energy required or used for lighting in buildings. The method of separate metering of the energy used for lighting will also give regular feedback on the effectiveness of the lighting control.

The methodology of energy estimation not only provides values for the Lighting Energy Numeric Indicator (LENI) but it will also provide input for the heating and cooling load estimations for the combined total energy performance of building indicator.

Figure 1 gives an overview of the methodology and the flow of the processes involved.

NOTE The dotted line linking preliminary annual LENI to the comprehensive method indicates the required follow-up of the budget calculation with the comprehensive calculation during the detailed lighting design process.

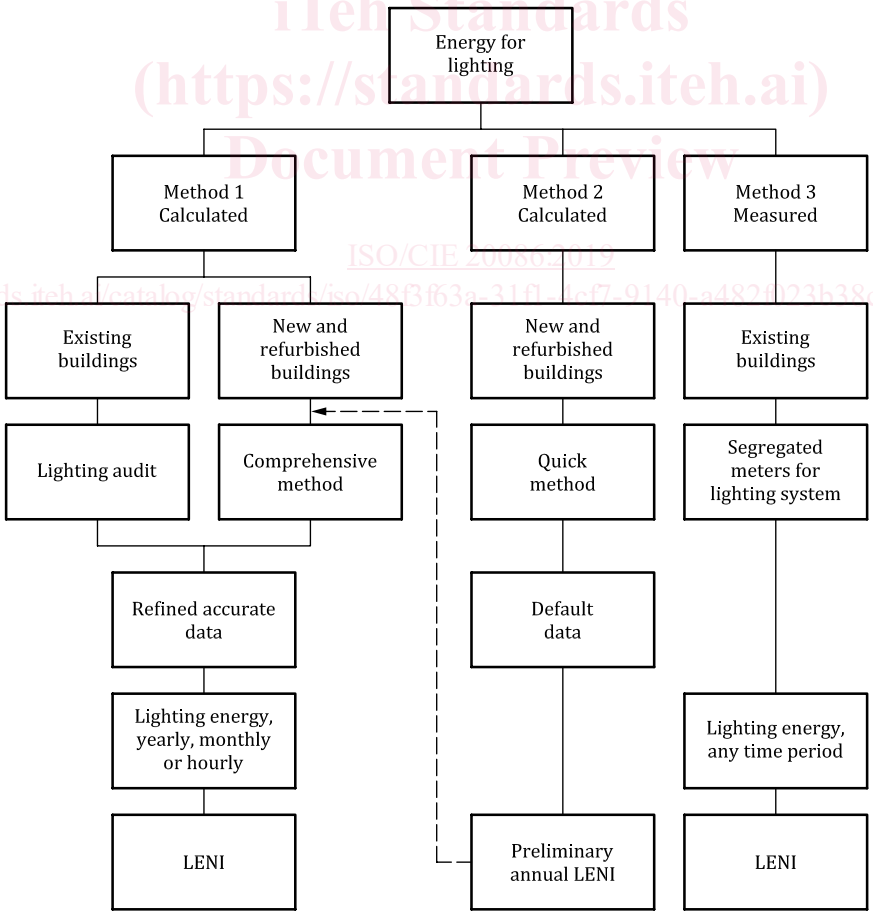

Figure 1 — Flow chart illustrating alternative routes to determine energy use

Light and lighting — Energy performance of lighting in buildings

1 Scope

This document specifies the methodology for evaluating the energy performance of lighting systems for providing general illumination inside non-residential buildings and for calculating or measuring the amount of energy required or used for lighting inside buildings.

This document does not cover lighting requirements, the design of lighting systems, the planning of lighting installations, the characteristics of lighting equipment (lamps, control gear and luminaires) and systems used for display lighting, desk lighting or luminaires built into furniture. This document does not provide any procedure for the dynamic simulation of lighting scene setting.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8995-1/CIE S 008, *Lighting of work places — Part 1: Indoor*

ISO 10916, *Calculation of the impact of daylight utilization on the net and final energy demand for lighting*

ISO 30061/CIE S 020, *Emergency lighting*

IEC 60598 (all parts), *Luminaires*

CIE S 017, ILV, *International Lighting Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE S 017 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
time step
t_s
period in which the energy is evaluated

Note 1 to entry: Measured in hour, month, year.

3.2
standby energy
energy required for charging batteries and/or the energy required for lighting controls during the time the electric lights are switched off

Note 1 to entry: Lighting controls and emergency battery charging circuits are only considered where power is supplied via a luminaire.

3.3
lighting control
device connected to the luminaire to vary the light output

Note 1 to entry: In this document lighting controls are only considered where power is supplied via a luminaire.

3.4
lighting system
set of light sources and/or lamps with luminaires and related equipment, if any, interacting together to satisfy lighting application requirements

Note 1 to entry: The lighting system can be dedicated to:

a) the support of (a) specified visual task(s) under specified conditions considering other requirements such as human comfort, safety, the appearance of the surrounding environment and energy consumption;

b) the support of other than human tasks, such as plant growth or breeding of animals.

Note 2 to entry: The lighting system can include physical components, communication protocols, user interfaces, software and networks to provide control and monitoring functions.

[SOURCE: CIE DIS 017:2016; Term 17-29-029]

3.5
expenditure factor
expense factor
effort factor
indicator of the energy efficiency of a given lighting system compared to a reference system

4 Symbols and abbreviations

4.1 Symbols

For the purposes of this document, the specific symbols listed in Table 1 apply.

Table 1 — Symbols and units

Symbol	Name of quantity	Unit
A	Total useful area	m^2
A_D	Partial area which is lit by daylight	m^2
A_{ND}	Area not lit by daylight	m^2
A_s	Sum of task areas within the room	m^2
D	Daylight factor	%
D_{class}	Daylight availability classification	1
e_L	Expenditure factor for lighting systems	1
$e_{L,C}$	Partial expenditure factor for constant illuminance control	1
$e_{L,D}$	Partial expenditure factor for daylight dependant lighting control	1
$e_{L,ES}$	Partial expenditure factor for the electric lighting system	1
$e_{L,ES,del}$	Partial expenditure factor for delivery of electric light	1
$e_{L,ES,dis}$	Partial expenditure factor for distribution of electric light	1
$e_{L,ES,gen}$	Partial expenditure factor for generation of electric light	1
$e_{L,O}$	Partial expenditure factor for occupancy dependant lighting control	1
E_m	Maintained illuminance	lx
E_{sur}	Maintained illuminance on immediate surround of task area	lx
E_{task}	Maintained illuminance on the task area	lx

Table 1 *(continued)*

Symbol	Name of quantity	Unit
F_A	Absence factor	1
f_B	Factor for the efficiency of the operating device	1
F_c	Constant illuminance factor	1
F_{CA}	Factor for reduced power of area	1
F_{cc}	Factor for the efficiency of the constant illuminance control	1
F_D	Daylight dependency factor	1
$F_{D,C}$	Lighting control factor	1
$F_{D,S}$	Daylight supply factor	1
F_L	Factor for light source efficiency	1
f_m	Maintenance factor	1
F_{CMF}	Correction factor for maintenance factor	1
F_o	Occupancy dependency factor	1
F_{oc}	Controls function factor	1
F_u	Utilization factor of the luminaire	1
$F_{u,e}$	Utilization factor for determination of the energy use	1
h_m	Mounting height of luminaire	m
K	Room Index	1
L_x	time period at which *x* % of the measured initial luminous flux value is maintained	h
L_R	Length of room	m
N_i	Number of days in month *i*	d
n_{La}	Number of lamps in the luminaire	1
P	Installed electric power density	W/m^2
p	Specific electrical evaluation power	W/(m^{2}lx)
$P_{c,i}$	Control standby power of luminaire *i*	W
P_e	Electrical evaluation power density for determination of the energy use	W/m^2
P_{em}	Total emergency standby power	W
$P_{e,i}$	Emergency charging power of luminaire *i*	W
P_i	Power of luminaire *i*	W
P_j	Power density of area *j*	W/m^2
$P_{j,lx}$	Illuminance-normalized power density of area *j*	W/(m^{2}lx)
P_n	Total power of *n* luminaires	W
P_{pc}	Total controls standby power	W
P_r	Lamp rated power	W
Q_{LENI}	Lighting energy numeric indicator (LENI) for a building	kWh/m^2
$Q_{LENI,sub}$	Lighting energy numeric indicator for an area or relevant zone	kWh/m^2
R_a	General colour rendering index	1
t_D	Daylight time	h
t_N	Daylight absence time	h
t_s	Time step	hour, month, year
t_{tot}	Total operating hours	h
t_y	Number of hours in a standard year	h
W	Total annual energy used for lighting	kWh
W_{az}	Annual energy required for lighting for an area or a zone	kWh

Table 1 *(continued)*

Symbol	Name of quantity	Unit
$W_{L,t}$	Total energy for illumination	kWh
W_{mt}	Metered energy	kWh
$W_{P,t}$	Total energy for standby	kWh
w_R	Width of room	m
W_t	Energy per time step	kWh
W_{us}	Energy used for lighting	Wh
W_{nd}	Energy needed for lighting	Wh
W_{pc}	Standby energy density for automatic lighting controls of the luminaire per year	kWh/m^2
W_{pe}	Standby energy density for battery charging of emergency luminaires per year	kWh/m^2
η_L	Luminaire luminous efficacy	lm/W
η_{LB}	Luminaire light output ratio	1
η_R	Utilance	1

4.2 Subscripts

For the purposes of this document, the specific subscripts listed in Table 2 apply.

Table 2 — Subscripts

i	Relevant element under consideration or Month number, 1 – 12
j	Relevant area under consideration

5 Description of the methods

5.1 General

This document covers three methods for the assessment of the energy required for electric lighting within a building, either by calculation (method 1 and method 2) or by direct metering of the lighting circuit (method 3). The calculation method 1 offers two options,

1) for new or refurbished buildings, and

2) for existing buildings.

For new and refurbished buildings it also offers a quick calculation method 2 for the annual energy estimation.

This document offers calculation methods, with different levels of accuracy for the installed power, occupancy estimation and daylight availability.

Method 1 provides the most accurate calculation procedure and it relies upon a comprehensive lighting scheme design as the main input to the energy calculation.

Method 2 provides a quick estimation aimed for pre-design calculations and employs default values. Default values are provided in Annex A.

Method 3 provides the most accurate energy use for lighting information but can only be used after the building has been commissioned and occupied. This method can also be linked to the Building Management System (BMS) of the building to provide continuous smart metering.

5.2 Output of the method 1— Comprehensive method

This method covers the calculation of the energy requirements of lighting systems in non-residential buildings where a comprehensive lighting system design has been performed. This calculation method is suitable for use during the design of new or refurbished buildings and for assessing existing buildings.

The method output shall be in terms of kilowatt hours per time step for the building. The output value shall be normalized for the considered time step to square meters of the useful area to give the sub-LENI value. If the time-step is yearly this is the Lighting Energy Numeric Indicator LENI.

The time step of the output can be:

— yearly,

— monthly, or

— hourly,

in accordance with the time step of the input data.

5.3 Optional methods

5.3.1 Method 2 — Quick calculation method

This method covers the calculation of the energy requirements of lighting systems for non-residential buildings where a comprehensive lighting system design has not been performed. The method makes use of quick calculation and default data and the result gives budget values.

The method output shall be in terms of kilowatt hours per year for the building. This yearly output value shall be normalized to square meters of the useful area to give the LENI.

The time step of the output shall be yearly.

This method is suitable for use during the conceptual stage of design of new or refurbished buildings.

5.3.2 Method 3 — Direct metering method

This method covers the direct measurement of the energy used by lighting system in non-residential buildings by segregated direct metering. This method gives the true value of energy used by the lighting system and can be used to verify the values obtained by the calculation methods.

The method output shall be in terms of kilowatt hours per time step for the building. The yearly output value shall be normalized to square meters of the useful area to give the LENI.

The time step of the output can be:

— yearly,

— monthly, or

— hourly,

in accordance with the time step of the input data.

This method is suitable for use in existing buildings where the lighting circuit is sufficiently segregated to allow separate metering.

This method is applicable to buildings with facilities for separate metering of the electricity used for all lighting within the building. The metering can alternatively be by the BMS arrangement.

The calculated or measured annual energy required for lighting can be normalized to a unit area to generate the LENI. LENI provides a comparable measure of the energy performance of the lighting installation in the buildings. When the output value is obtained for other time steps it shall be normalised to the unit area to give the sub-LENI value.

6 Method 1 — Calculation of the energy required for lighting

6.1 Output data

The output data of this method are listed in Table 3.

Table 3 — Output data of this method

Description	Symbol	Unit
Specified time step, e.g. hourly, monthly or annually	t_s	hour, month, year
Energy used for lighting (in kWh) per time step (e.g. hourly, monthly or annually) within rooms or zones	W_t	kWh

LENI is the area normalized annual energy used for lighting within the building [kWh/m^2]. LENI produced by method 1 provides the most accurate calculated Q_{LENI}.

6.2 Calculation time steps

The methods described in clause 6 are suitable for the following calculation time steps:

— Yearly – Taken as 8 760 h;

— Monthly – Taken as an average of 730 h;

— Hourly – 1 h derived from monthly calculated value divided by 730.

NOTE If more accurate data for occupancy and daylight is available for hourly intervals this data can be used.

6.3 Input data

6.3.1 Lighting system data

For the comprehensive calculation method the energy estimation shall be based upon the electric lighting system that provides illumination in accordance with the requirements for non-residential buildings of ISO 8995-1/CIE S 008 for lighting of indoor work places and requirements for emergency lighting according to ISO 30061/CIE S 020.

It is important that for all buildings the lighting solution shall combine daylight, if available, and electric light to fulfil all requirements in accordance with ISO 8995-1/CIE S 008 and the general and specific lighting criteria for the places within the buildings.

6.3.1.1 New or refurbished building lighting system

The lighting scheme design process of the electric lighting system for all rooms and zones within the building shall deliver as output the required type and number of luminaires and these shall be listed in the product schedule.

NOTE 1 The comprehensive lighting system design process is not part of this document.

The lighting system design shall give the following input data and details for each room and zone of the building:

— the types of luminaires, identified by a unique product reference code;

— the quantities of each specific type of luminaire;

— the control technique and device types;

— the maintenance factor (f_m) assumed in the design.

NOTE 2 The specific type of the luminaire includes information on the product as well as the lamp and ballast combination if applicable.

All luminaires listed for use shall comply with the requirements specified in IEC 60598 (all parts).

6.3.1.2 Existing building lighting system

The lighting system shall be surveyed to give the following input data and details for each room and zone of the building:

— the types of luminaires, identified by a unique product reference code;

— the quantities of each specific type of luminaire;

— the control technique and device types;

— the maintenance factor (f_m) defined by the maintenance schedule.

6.3.2 Product data

6.3.2.1 General

Where the comprehensive method is being used, the data in Table 4 to 7 shall be specified for each product type given in the product schedule:

Table 4 — Luminaire identification

Code	Description

Table 5 — Power of luminaire *i* (P_i)

Code	Power W

Table 6 — Control standby power of luminaire *i* ($P_{c,i}$)

Code	Power W

Table 7 — Emergency charging power of luminaire *i* ($P_{e,i}$)

Code	Power W

In the case of existing buildings where the luminaire data is not available from the manufacturer the method described in Annex C shall be used for obtaining the value of the maximum luminaire power.

NOTE In this document product means light sources and/or lighting controls and/or emergency battery charging circuits where power is supplied via a luminaire.

6.3.2.2 Luminaire description data (qualitative)

The product description data shall indicate the product characteristics and state the functional capabilities regarding dimming control, integral detectors and emergency lighting facility.

6.3.2.3 Luminaire technical data

The luminaire technical data, in accordance with Table 4 to 7, shall be the values declared by the manufacturer in accordance with the certified measurements that are performed in accordance with the relevant product standards. If standby energy density values declared by the manufacturer are not available, then default values are given in Table A.1 for information.

Declared values are given at standard reference test conditions. Declared values shall be adjusted in accordance with the actual operating conditions. This adjustment is part of the calculation procedure. This applies both to standard test values and to field test measurements.

6.3.3 System design data

Calculations shall be made for each area of a zone or building to establish the installed lighting power, P_n, P_{em} and P_{pc}, and to estimate the impact of occupancy, daylight and over design/maintenance factors on the lighting controls by determining the values of the dependency factors, F_o, F_D and F_c. These shall be presented as shown in Table 8.

Table 8 — System design data

Area Code	F_o	F_D	F_c	P_n	P_{em}	P_{pc}

6.3.4 Operating conditions

The operating conditions for the lighting system are specified in the design of the lighting system to fulfil the lighting requirements for the tasks or activity in a zone or building. The electric lighting system shall be designed to meet all the relevant lighting criteria and the system shall be managed by controls. The controls shall be manually or automatically operated. Details of control types and their operation and effectiveness are given in CEN/TR 15193-2.

In addition the occupancy and activity patterns shall be defined to allow the evaluation of t_D and t_N for each area of a zone or building. These shall be presented as shown in Table 9.

Table 9 — Times for operating conditions

Area Code	t_D	t_N

6.3.5 Constants and physical data

Number of hours in a standard year (t_y) – defined as 8 760 h.