

Energy performance of buildings — Energy requirements for lighting

ICS 91.140.99; 91.160.10

National foreword

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Foreword

This document (EN 15193:2007) has been prepared by Technical Committee CEN/TC 169 “Light and lighting”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2008, and conflicting national standards shall be withdrawn at the latest by March 2008.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This European Standard was devised to establish conventions and procedures for the estimation of energy requirements of lighting in buildings, and to give a methodology for a numeric indicator of energy performance of buildings. It also provides guidance on the establishment of notional limits for lighting energy derived from reference schemes.

Having the correct lighting standard in buildings is of paramount importance and the convention and procedures assume that the designed and installed lighting scheme conforms to good lighting practices. For new installations the design should be to EN 12464-1.

This European Standard also gives advice on techniques for separate metering of the energy used for lighting that will give regular feedback on the effectiveness of the lighting controls.

The methodology of energy estimation not only provides values for the numeric indicator but will also provide input for the heating and cooling load impacts on the combined total energy performance of building indicator.

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

The methodology and format of the presentation of the results would satisfy the requirements of the EC Directive on Energy Performance of Buildings 2002/91/EC.

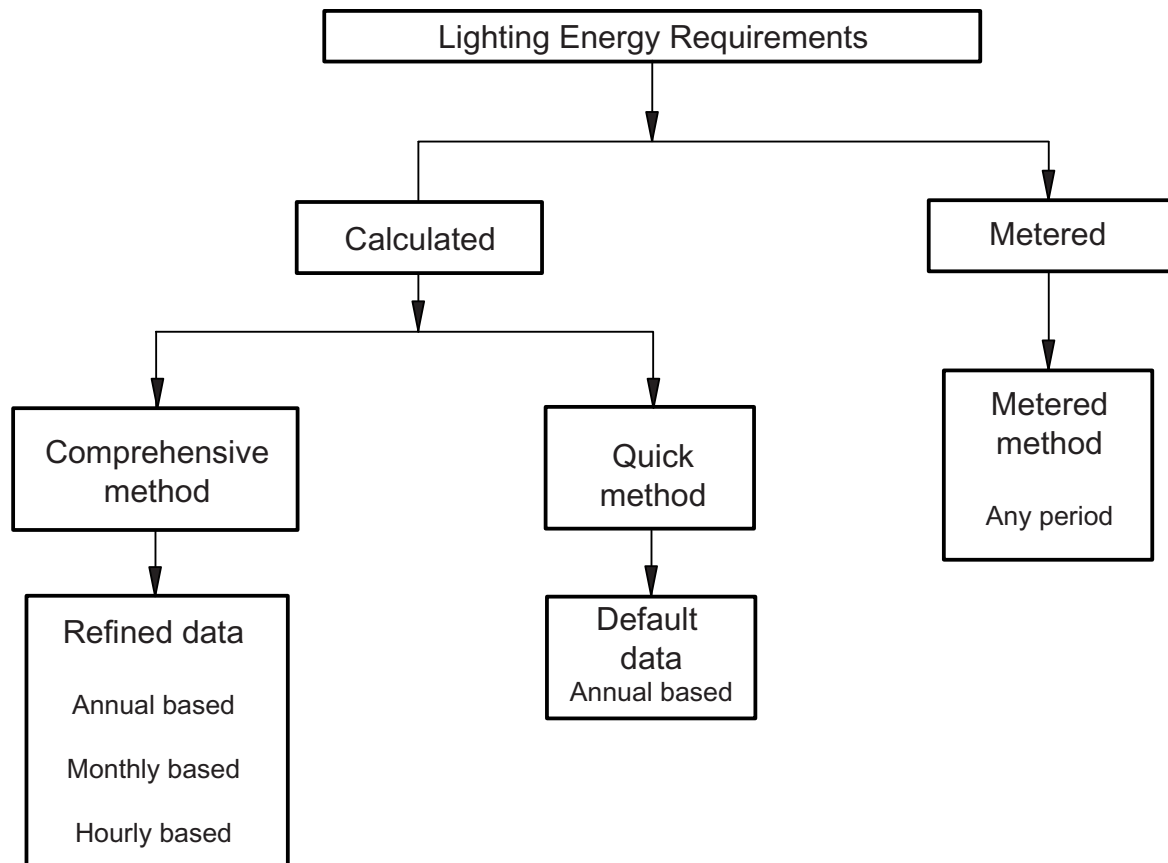


Figure 1 — Flow chart illustrating alternative routes to determine energy use

1 Scope

This European Standard specifies the calculation methodology for the evaluation of the amount of energy used for indoor lighting inside the building and provides a numeric indicator for lighting energy requirements used for certification purposes. This European Standard can be used for existing buildings and for the design of new or renovated buildings. It also provides reference schemes to base the targets for energy allocated for lighting usage. This European Standard also provides a methodology for the calculation of instantaneous lighting energy use for the estimation of the total energy performance of the building. Parasitic powers not included in the luminaire are excluded.

In this European Standard, the buildings are classified in the following categories: offices, education buildings, hospitals, hotels, restaurants, sports facilities, wholesale and retail services and manufacturing factories.

In some locations outside lighting may be fed with power from the building. This lighting may be used for illumination of the façade, open-air car park lighting, security lighting, garden lighting etc. These lighting systems may consume significant energy and if they are fed from the building, this load will not be included in the Lighting Energy Numeric Indicator or into the values used for heating and cooling load estimate. If metering of the lighting load is employed, these loads may be included in the measured lighting energy.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 1838, *Lighting applications — Emergency lighting*

EN 12193, *Light and lighting — Sports lighting*

EN 12464-1:2002, *Light and lighting — Lighting of work places — Part 1: Indoor work places*

EN 60570, *Electrical supply track systems for luminaires (IEC 60570:2003, modified)*

EN 60598 (all parts), *Luminaires*

EN 61347 (all parts), *Lamp controlgear*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

built-in luminaires

fixed luminaires installed to provide illumination in the building

3.2

control gear

components required to control the operation of the lamp(s)

3.3 **power**

3.3.1 **luminaire power** **(P_l)**

electrical power from the mains supply consumed by the lamp(s), control gear and control circuit in or associated with the luminaire, measured in watts which includes any parasitic power when the luminaire is turned on

NOTE The rated luminaire power (P_l) for a specific luminaire may be obtained from the luminaire manufacturer.

3.3.2 **total installed lighting power in the room or zone** **(P_n)**

power of all luminaires in the room or zone, measured in watts

$$P_n = \sum_i P_{li} \text{ [W]} \quad (1)$$

3.3.3 **parasitic power**

3.3.3.1 **luminaire parasitic power** **(P_{pli})**

electrical power from the mains supply consumed by the charging circuit of emergency lighting luminaires and the standby power for automatic controls in the luminaire when lamps are not operating, measured in watts

$$P_{pli} = P_{cli} + P_{eii} \text{ [W]} \quad (2)$$

3.3.3.2 **parasitic power of the controls only during the time with the lamps off (P_{cli})**

stand-by power for any controls and/or any battery charging power consumed by an emergency lighting system when the luminaire is turned off, measured in watts

3.3.3.3 **emergency lighting charging power** **(P_{eii})**

input power to the charging circuit of emergency luminaires when the lamps are not operating, measured in watts

3.3.4 **total installed parasitic power of the controls in the room or zone** **(P_{pci})**

input power of all control systems in luminaires in the room or zone when the lamps are not operating, measured in watts

$$P_{pci} = \sum_i P_{cli} \text{ [W]} \quad (3)$$

3.3.5

total installed charging power of the emergency lighting luminaires in the room or zone (P_{em})

input charging power of all emergency lighting luminaires in the room or zone, measured in watts

$$P_{em} = \sum_i P_{ei} \quad [W] \quad (4)$$

3.4

energy

3.4.1

total energy used for lighting

(W_t)

energy consumed in period t , by the sum of the luminaires when the lamps are operating, plus the parasitic loads when the lamps are not operating, in a room or zone, measured in kWh

3.4.2

energy consumption used for illumination

($W_{L,t}$)

energy consumed in period t , by the luminaire when the lamps are operating to fulfil the illumination function and purpose in the building, measured in kWh

3.4.3

luminaire parasitic energy consumption

($W_{P,t}$)

parasitic energy consumed in period t , by the charging circuit of emergency lighting luminaire and by the standby control system controlling the luminaires when the lamps are not operating, measured in kWh

3.5

time

3.5.1

operating time

(t)

time period for the energy consumption measured in hours [h]

3.5.2

annual operating time

(t_o)

annual number of operating hours of the lamp(s) and luminaires with the lamps operating

$$t_o = t_D + t_N \quad [h] \quad (5)$$

NOTE This number is determined depending on the building use.

3.5.3

standard year time

(t_y)

time taken for one standard year to pass, taken as 8 760 h

3.5.4

daylight time usage

(t_D)

operating hours during the daylight time, measured in hours

3.5.5

non-daylight time usage

(t_N)

operating hours during the non-daylight time, measured in hours

3.5.6

emergency lighting charge time

(t_{em})

operating hours during which the emergency lighting batteries are being charged, measured in hours

3.5.7

scene setting operation time

(t_s)

operating hours of the scene setting controls, measured in hours

3.6

useful area

(A)

floor area inside the outer walls excluding non-habitable cellars and un-illuminated spaces, measured in m²

3.7

dependency factors

3.7.1

daylight dependency factor

(F_D)

factor relating the usage of the total installed lighting power to daylight availability in the room or zone

3.7.2

occupancy dependency factor

(F_O)

factor relating the usage of the total installed lighting power to occupancy period in the room or zone

3.7.3

absence factor

(F_A)

factor relating to the period of absence of occupants

3.7.4

constant illuminance factor

(F_C)

factor relating to the usage of the total installed power when constant illuminance control is in operation in the room or zone

3.8

Maintenance Factor

(MF)

ratio of the average illuminance on the working plane after a certain period of use of a lighting installation to the initial average illuminance obtained under the same conditions for the installation

NOTE CIE 97 gives further information.

3.9

Lighting Energy Numeric Indicator

(LENI)

numeric indicator of the total annual lighting energy required in the building and given in kWh (m² x year)

NOTE The *LENI* can be used to make direct comparisons of the lighting energy used in buildings that have similar functions but are of different size and configuration.

4 Calculating energy used for lighting

4.1 Total energy used for lighting

4.1.1 Total estimated energy

The total estimated energy required for a period in a room or zone shall be estimated by the following equation:

$$W_t = W_{L,t} + W_{P,t} \text{ [kWh]} \quad (6)$$

where

An estimate of the lighting energy required to fulfil the illumination function and purpose in the building ($W_{L,t}$) shall be established using the following equation:

$$W_{L,t} = \sum \{ (P_n \times F_c) \times [(t_D \times F_o \times F_D) + (t_N \times F_o)] \} / 1\,000 \text{ [kWh]} \quad (7)$$

An estimate of the parasitic energy ($W_{P,t}$) required to provide charging energy for emergency lighting and for standby energy for lighting controls in the building shall be established using the following equation:

$$W_{P,t} = \sum \{ \{ P_{pc} \times [t_y - (t_D + t_N)] \} + (P_{em} \times t_e) \} / 1\,000 \text{ [kWh]} \quad (8)$$

NOTE 1 The total lighting energy can be estimated for any required period t (hourly, daily, weekly, monthly or annually) in accordance with the time interval of the dependency factors used.

NOTE 2 For existing buildings, $W_{P,t}$ and $W_{L,t}$ can be established more accurately by directly and separately metering the energy supplied to the lighting (see Clause 5).

NOTE 3 This estimation does not include the power consumed by control systems remote from the luminaire and not drawing power from the luminaire. Where known this should be added.

NOTE 4 Equation (8) does not include the power consumed by a central battery emergency lighting system.

4.1.2 Total annual energy used for lighting

$$W = W_L + W_P \text{ [kWh/year]} \quad (9)$$

where

An estimate of the annual lighting energy required to fulfil the illumination function and purpose in the building (W_L) and annual parasitic energy (W_P) required to provide charging energy for emergency lighting and for standby energy for lighting controls in the building shall be established by Equations (7) and (8) respectively.

4.2 Lighting Energy Numeric Indicator (*LENI*)

Lighting Energy Numeric Indicator for the building shall be established using the following equation:

$$LENI = W/A \text{ [kWh/(m}^2 \times \text{year)]} \quad (10)$$

where

W is the total annual energy used for lighting [kWh/year];

A is the total useful floor area of the building [m²].

5 Metering

5.1 General

The lighting consumption shall be separately measured using one of the following methods:

- a) kWh meters on dedicated lighting circuits in the electrical distribution;
- b) local power meters coupled to or integrated in the lighting controllers of a lighting management system;
- c) a lighting management system that can calculate the local consumed energy and make this information available to a building management system (BMS);
- d) a lighting management system that can calculate the consumed energy per building section and make this information available in an exportable format, e.g. a spread sheet format;
- e) a lighting management system that logs the hours run, the proportionality (dimming level) and relates this to its internal data base on installed load.

NOTE The measured value may be compared with the real kilowatt hours consumption measured during commissioning of the building.

5.2 Load segregation

The network of a BMS/lighting management system shall provide the same function in segregation as in the power distribution.

5.3 Remote metering

- a. Remote metering is recommended for buildings having completely segregated power distribution systems.
- b. Remote metering in buildings can also be used for more intelligent (lighting management) systems to provide data.

NOTE Annex A gives examples of metering methods.

6 Calculation of lighting energy in buildings

6.1 Installed lighting power

6.1.1 General

There are two forms of installed power in buildings, luminaire power and parasitic power.

Luminaire power, which provides power for functional illumination shall conform to EN 12193 for lighting of sports facilities and EN 12464-1 for lighting of indoor work places.

Parasitic power, which provides power for lighting control systems and for charging batteries for emergency lighting shall conform to EN 1838.

6.1.2 Luminaire

Luminaires and electrical components of luminaires shall be designed and constructed in accordance with the relevant parts of EN 60598, EN 60570 and/or EN 61347.

6.1.3 Luminaire power (P_i)

The total rated power (in watts) of a specific luminaire should be obtained in accordance with Annex B.

6.1.4 Parasitic powers (P_{ci} and P_{ei})

Parasitic power should be obtained in accordance with Annex B.

6.2 Calculation methods

6.2.1 Quick method

When using the quick method of estimation of the annual lighting energy estimation for typical building types, Equation (9) shall be used.

NOTE 1 The energy requirement estimation by the quick method will yield higher *LENl* values than that obtained by the more accurate comprehensive method described in 6.3.

NOTE 2 If the national values are not available, use the default values for t_D , t_N , F_c , F_D , F_O and W_p are given in Annexes E, F and G.

6.2.2 Comprehensive method

6.2.2.1 General

The comprehensive method allows for a more accurate determination of the lighting energy estimations for different periods e.g. annual or monthly.

When using the comprehensive method of lighting energy estimations Equation (6) shall be used for the required period t .

NOTE 1 The daylight dependency factor (F_D) for a room or zone can be determined as described in Annex C.

NOTE 2 The occupancy dependency factor (F_O) for a room or zone can be determined as described in Annex D.

NOTE 3 This method may be used for any periods and for any locations provided that the full estimation of occupancy and daylight availability is predicted.

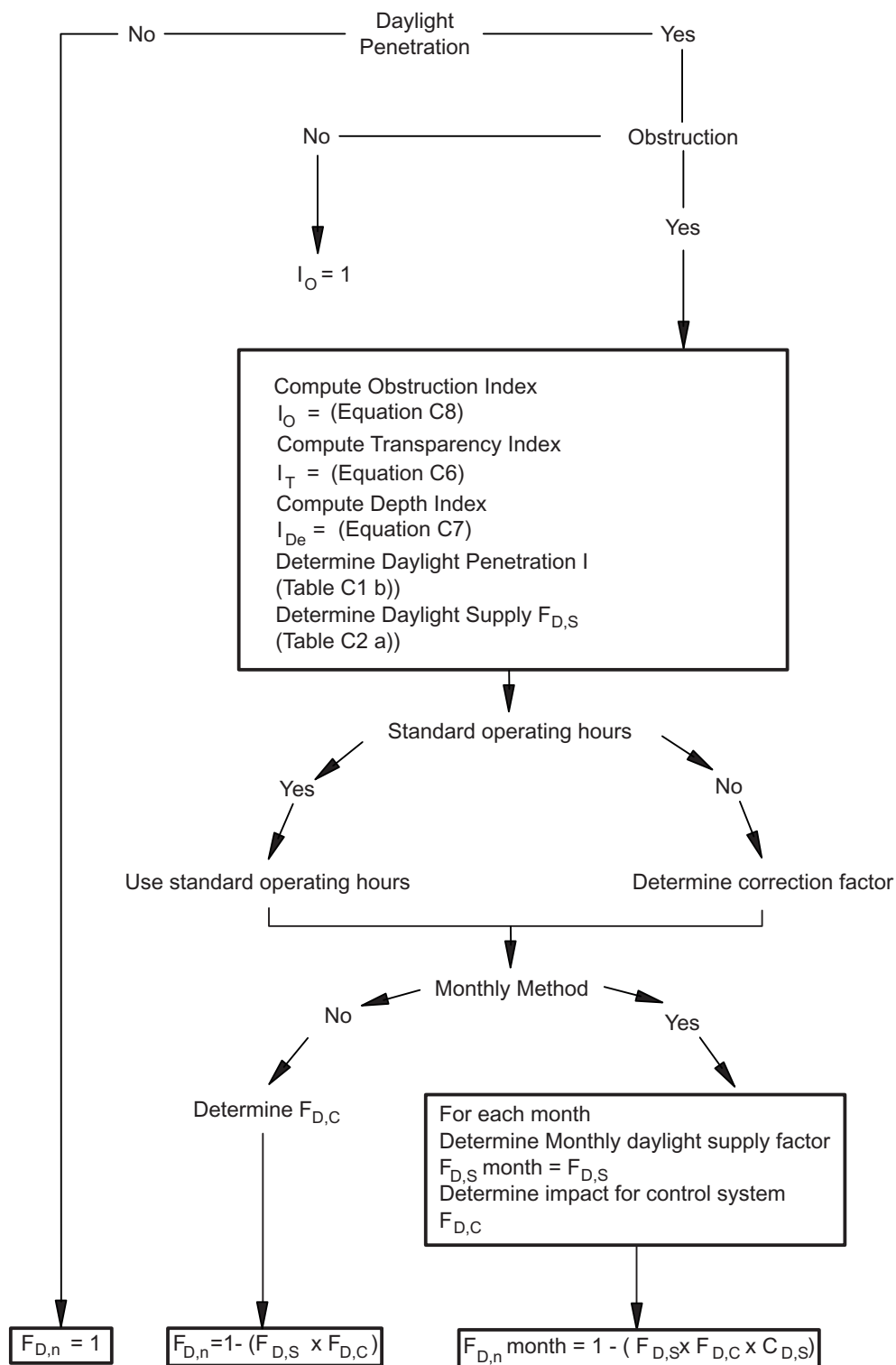


Figure 2 — Flow chart illustrating the determination of the daylight dependency factor $F_{D,n}$ in a zone

6.2.2.2 Determination of the daylight dependency factor $F_{D,n}$

The determination of the daylight dependency factor $F_{D,n}$ for the n^{th} room or zone should be made by the methods described in Annex C for annual and monthly time period and the process illustrated in the flow chart (Figure 2).

The daylight dependency factor $F_{D,n}$ for room or zone in the building is determined as a function of the daylight supply factor $F_{D,S,n}$ and the daylight dependent electric lighting control factor $F_{D,C,n}$ and given by the following equation:

$$F_{D,n} = 1 - (F_{D,S,n} \times F_{D,C,n}) \quad (11)$$

where

$F_{D,S,n}$ is the daylight supply factor that takes into account the general daylight supply in the zone n. It represents, for the considered time interval, the contribution of daylight to the total required illuminance in the considered zone n. See C.3.1.3 and C.3.2.2;

$F_{D,C,n}$ is the daylight control factor that accounts for the daylight depending electric lighting control system's ability to exploit the daylight supply in the considered zone n see C.4.

NOTE 1 $F_{D,n}$ can be determined for any time period (annual, monthly or hourly). The factor needs to be adjusted according to the period of the operation time at daytime t_D .

NOTE 2 Other daylight supply systems that rely on enhancements to increase or make possible daylight penetration beyond the perimeter zones are available. These are not explicitly covered in this European Standard but may be calculated by using daylight factors or other methods for the calculation of F_D .

NOTE 3 In zones without daylight availability, $F_D = 1$.

NOTE 4 The method given in Annex C can be used to consider location and climate dependent aspects of daylight supply.

6.2.2.3 Determination of occupancy dependency factor $F_{O,n}$

The occupancy dependency factor $F_{O,n}$ for a room or zone should be determined by the methods described in Annex D.

6.2.3 Determination of constant illuminance factor F_c

The determination of the constant illuminance factor F_c for a room or zone can be determined as described in Annex E.

7 Benchmark of lighting energy requirements

Benchmark data of the total lighting energy requirement estimation during the design of new or refurbished buildings should be determined from a set of default values for lighting energy requirements as provided in Annex F. The data shows the potential installed power density required for lighting the specified building types. The values are based on meeting the necessary and desired lighting criteria applied to the building. The values are average for the building and can vary substantially for different rooms or zones in the building.

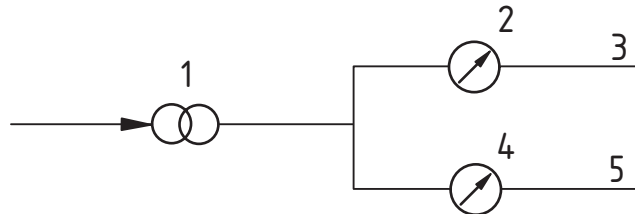
8 Lighting design and practice

Lighting design and practice is continuously evolving and may have substantial consequences on the energy requirement for lighting. A number of these influencing factors have been considered and described in Annex H under the following headings:

- **Individual dimming**
A lighting control system used locally to work places to provide individual lighting comfort by adjustment to meet personal preferences.
- **Algorithmic light**
A lighting system to take non-visual biological effects into account by automatic changing of light level, direction and colour temperature.
- **Light pipes**
Light pipes are reflective tubes that direct sunlight and daylight from apertures in the building roof to luminaires in the interior.
- **Lighting installations with scene setting**
A lighting system that permits pre-setting of various illumination scenes in time and location for different activities in a room or zone.
- **Daylight guidance**
Energy savings may be obtained by employing daylight-guiding systems that also allow the penetration of sufficient amounts of daylight into deeper spaces, whilst maintaining control of glare and overheating.

Annex A (informative)

Metering of lighting circuit



Key

- | | |
|----------------------------|----------------------|
| 1 primary power | 4 kWh lighting meter |
| 2 kWh meter other circuits | 5 lighting circuit |
| 3 power circuit | |

Figure A.1 — kWh meters on dedicated lighting circuits in the electrical distribution

In the example of Figure A.1, the kWh meter for lighting is in parallel to the kWh meter for the rest of the electrical installation. The consumption for the total building is in this case the sum of both meters.

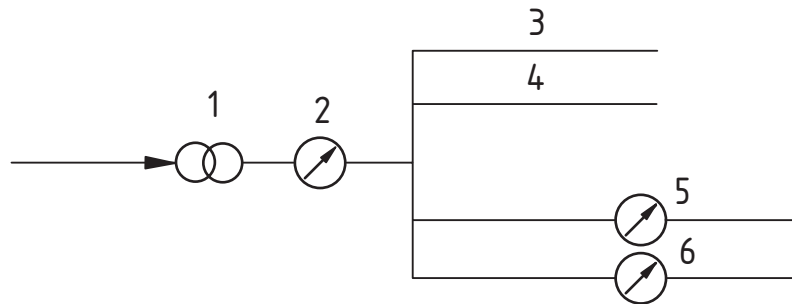
$$W = W_{\text{light metered}} \text{ [kWh/year]} \quad (\text{A.1})$$

In the example of Figure A.2, the kWh meters for lighting distributed over the different floors are placed in series with the central kWh meter of the building. In this case the central kWh meter registers the total energy consumption including the lighting consumption.

Equation for monitoring:

$$W = W_{\text{light metered}} = \sum_{\text{all floors}} (\text{kWh @ date} - \text{kWh @ (date - 12 months)}) \text{ [kWh/year]} \quad (\text{A.2})$$

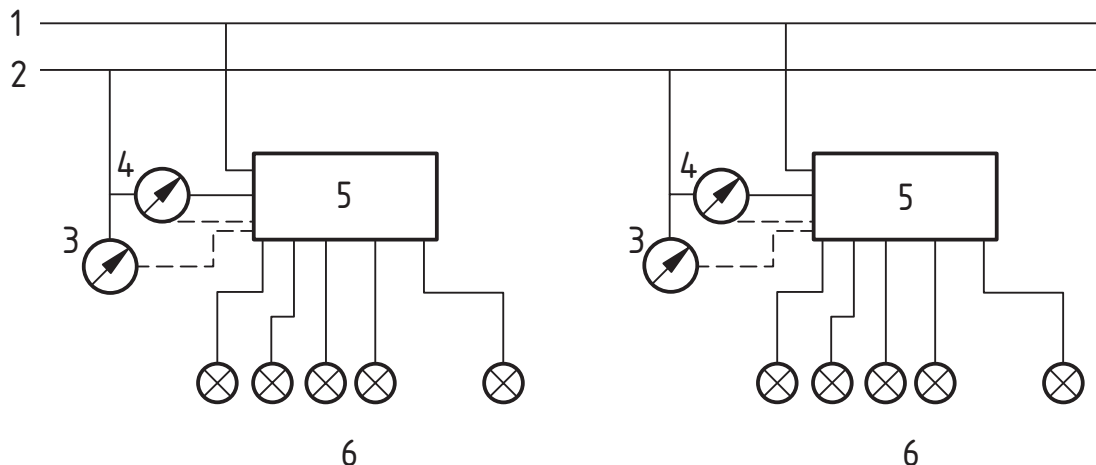
Local kWh meter values (as in Figure A.2) could be read and totalled by a Building Management System. No corrections for occupancy or control types are necessary.



Key

- | | |
|---------------------------|----------------------------------|
| 1 primary power | 4 power circuit 2 |
| 2 kWh meter – total power | 5 kWh meter – lighting circuit 1 |
| 3 power circuit 1 | 6 kWh meter – lighting circuit 2 |

Figure A.2 — Building with segregation of lighting circuits per floor and separately measured



Key

- | | |
|------------------|--------------------|
| 1 bus line | 4 ampere meter |
| 2 230 volt power | 5 light controller |
| 3 volt meter | 6 luminaires |

Figure A.3 — Volt and ampere meters coupled to the inputs of the lighting controllers

NOTE 1 Some systems include a power factor meter.

Local power meters coupled to or integrated in the lighting controllers of a lighting management system. Information on the local consumed energy is made available to a building management system.

In Figure A.3, volt and ampere meters or watt meters are put on the power input of every lighting controller. The individual lighting controllers calculate the local consumed energy by integrating these values over time.

These values are made available via the bus line to either the central computer of the lighting system or the central computer of the building management system. The central computer can process this

information and present the consumed energy figures e.g. per area per month and/or for the total lighting of the building over a period of 12 months in an exportable format, such as a spread sheet.

Equation for monitoring:

$$W = W_{\text{light metered}} = \sum_{\text{all controllers}} \sum_{12 \text{ months}} (\text{kWh}_{\text{local}}) \quad [\text{kWh/year}] \quad (\text{A.3})$$

A lighting management system should log the hours run, the proportionality (dimming level) and relate this to its internal data base on installed load. The lighting management system makes this information available to a BMS for further reporting, or it can give the information in an exportable format.

The lighting controller sums the time per lighting load proportionally per output and makes these values available via the bus line.

NOTE 2 Energy consumption of luminaires not controlled by the lighting control system is not measured.

NOTE 3 Energy consumption of luminaires indirectly controlled via external contactors is measured.

Annex B

(informative)

Measurement method of total power of luminaires and associated parasitic power

B.1 Introduction

The values of rated luminaire input power and the rated parasitic input power should be used in the calculation of the energy performance of the building with respect to lighting requirements. The rated power values should be rounded to the nearest whole number for 10 W and above and should be to two significant figures when below 10 W. Both should be within a tolerance of $\pm 5\%$ of the claimed value.

B.2 Test measurement of luminaire power during normal operation

The object of the test is to measure the luminaire total input power during normal operation and the associated parasitic power (the standby input power for controls, sensing devices and charge power for emergency lighting circuits) at standard reproducible conditions that are close to the conditions of service for which the luminaire is designed. Ideally, these luminaire electrical measurements should be made during photometric tests.

B.3 Standard test conditions

Test conditions for photometric measurements should be in accordance with EN 13032-1:2004, 5.1, 5.2 and 5.3.

B.4 Electrical measuring instruments

Volt meters, ampere meters and watt meters should conform to the requirements for Class Index 0,5 or better (precision grade).

B.5 Test luminaires

The luminaire should be representative of the manufacturer's regular product. The luminaire should be mounted in the position in which it is designed to operate.

B.6 Test voltage

The test voltage at the supply terminals to the luminaire should be the rated voltage of the luminaire in accordance with EN 13032-1:2004, 5.2.2.

B.7 Luminaire power (P_i)

The luminaire power P_i , should be the value obtained in accordance with B.1 to B.6 or as declared by the manufacturer. The value should include losses in all lamp(s), ballast(s) and other component(s), for normal full output operating mode or at maximum light output if the luminaire includes a dimming control gear.

B.8 Luminaire parasitic power with lamps off (P_{pi})

The luminaire parasitic power P_{pi} should be the declared rated power of the luminaire for the luminaire operating in standby mode only. For controlled luminaires this is the power to the detectors, for emergency luminaires this is the steady state power for charging the batteries.

B.9 Emergency lighting luminaire parasitic input power (P_{ei})

The luminaire parasitic power P_{ei} for charging the batteries in emergency luminaires should be the declared rated power of the luminaire for the self-contained luminaire operating in battery charge mode only.

B.10 Lighting controls standby parasitic power (P_{ci})

The luminaire parasitic power P_{ci} for standby operation of the lighting controls and detectors without operating the lamps should be the declared rated parasitic power of the luminaire.

B.11 Default luminaire power for existing lighting installations

In existing buildings where the luminaire power (P_i) is not known this power can be estimated as:

- a) (the lamp rated power) $\times$ (number of lamps in the luminaire) for lamps operating directly on mains supply voltage e.g. mains voltage incandescent lamps, self ballasted fluorescent lamps etc.
- b) $1,2 \times$ (the lamp rated power) $\times$ (number of lamps in the luminaire) for lamps connected to the mains supply via a ballast or transformer in the luminaire.

B.12 Default parasitic energy for existing lighting installations

In existing buildings where the parasitic energy consumed is not known this annual energy can be estimated to consist of $1 \text{ kWh}/(\text{m}^2 \times \text{year})$ for emergency lighting and $5 \text{ kWh}/(\text{m}^2 \times \text{year})$ for the automatic lighting controls if used (total is $W_p = 6 \text{ kWh}/(\text{m}^2 \times \text{year})$).

Annex C (informative)

Determination of the daylight dependency factor $F_{D,n}$

C.1 General

This annex specifies a simplified approach for determining $F_{D,S,n}$ and $F_{D,C,n}$ and therefore $F_{D,n}$. Vertical façades with fenestration and rooflight solutions are considered. The method can be applied on an annual and on a monthly basis.

In accordance with 6.2.2.2, the daylight dependency factor $F_{D,n}$ is determined as a function of the daylight supply factor $F_{D,S,n}$ and the daylight dependent artificial lighting control factor $F_{D,C,n}$.

Therefore:

$$F_{D,n} = 1 - (F_{D,S,n} \times F_{D,C,n}) \quad (C.1)$$

The procedure illustrated in Figure C.1 incorporates the following 5 steps:

- a. segmentation of the building into zones with and without daylight access;
- b. determination of the impact of room parameters, façade geometry and outside obstruction on the daylight penetration into the interior space using the concept of the daylight factor;
- c. prediction of the energy saving potential described by the daylight supply factor $F_{D,S,n}$ as a function of local climate, maintained illuminance and daylight factor;
- d. determination of the exploitation of the available daylight by the type of lighting control by the daylight control factor $F_{D,C,n}$;
- e. conversion of annual value $F_{D,n}$ to monthly values.

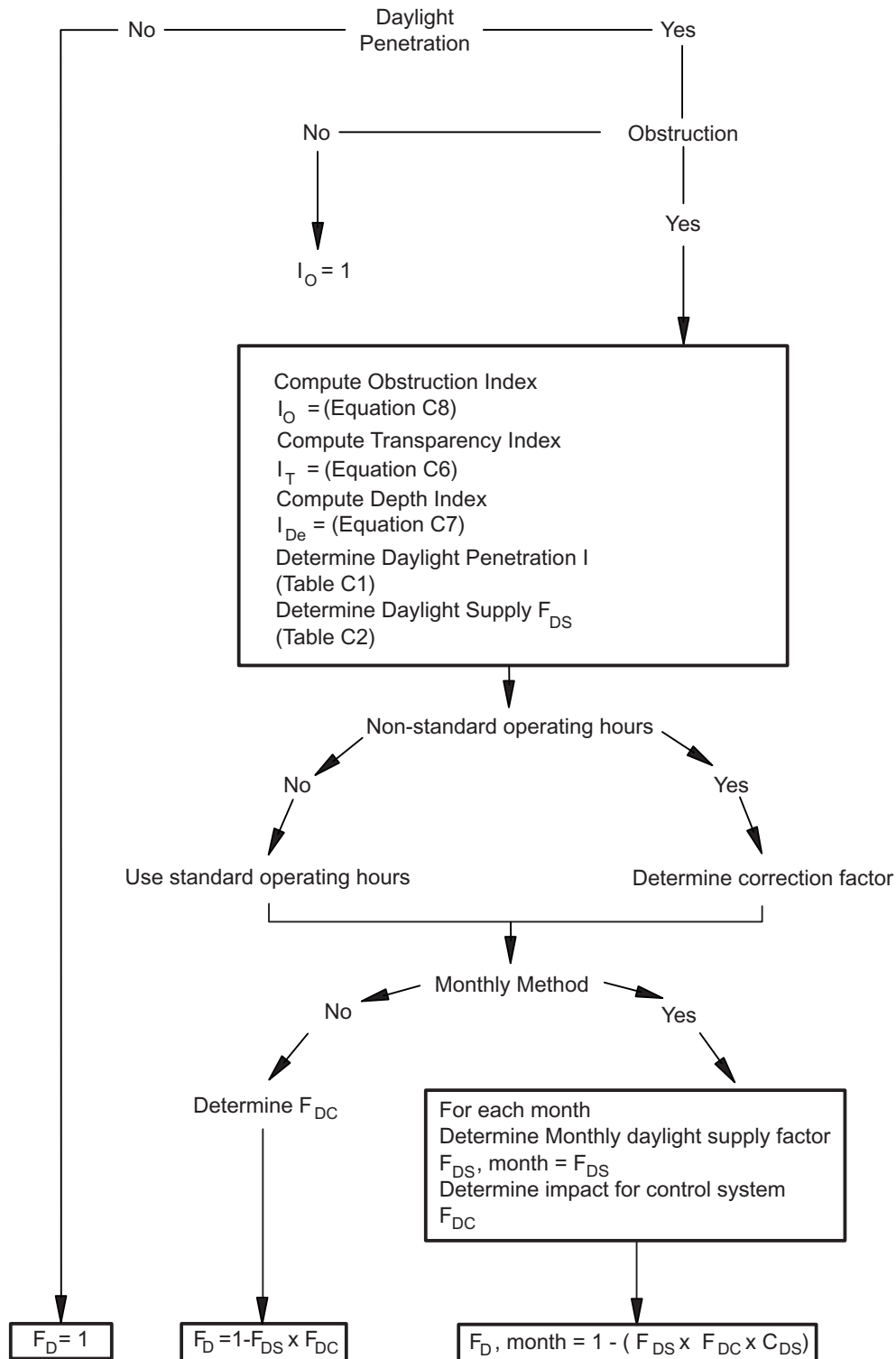


Figure C.1 — Flow chart illustrating the determination of the daylight dependency factor $F_{D,n}$ in a zone