A vehicle for energy-efficient lighting

EN 15193: Energy performance of buildings – Energy lighting requirements

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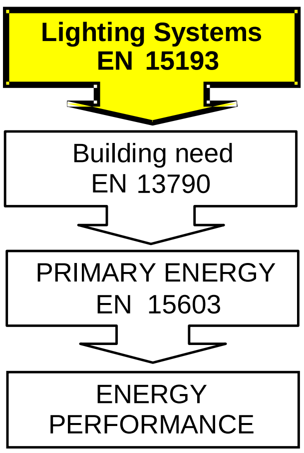

Figure 1: Position of EN 15193 in the set of EPBD standards. EN 15193 provides criteria relevant for the calculation of the building's energy need.

Energy – efficient lighting promises big saving potentials in non-residential buildings. The "Energy Performance of Buildings" Directive (EPBD) /1/ of the European commission intends to allocate these potentials. The EPBD requests to account for the lighting energy demand in the overall building energy balance. This will allow for instance trade-offs with heating and cooling energy demands.

The European Committee for Standardization (CEN) developed a set of standards covering the requirements of the EPBD. This information paper presents the general approach that should be used to determine lighting energy consumption within "prEN 15193-1 Energy performance of buildings - Energy requirements for lighting – Part 1: Lighting energy estimation" /2/.

In addition to providing the internal loads due to lighting, the method described in the standard can also be understood as a design tool, making it possible to optimise lighting energy requirements in a holistic approach integrating artificial lighting, daylighting and control systems. The EPBD will not only maintain good quality levels of lighting, as described for instance in the standard EN 12464-1 /3/, but in conjunction with the technical methods and standards within EN 15193 will also promote energy efficient artificial lighting systems and the efficient use of daylight.

1 > Scope of the standard

Standard EN 15193 specifies the metering and calculation methodology to be used for the evaluation of the amount of energy used for lighting in buildings. The standard can be applied to existing buildings and for the design of new or renovated buildings. It also provides a benchmarking system for different building types, making it possible to rank order the calculated or measured lighting energy demands. Several alternative routes for determining energy use are depicted in Figure 2. The general understanding is that this CEN document provides a framework, an umbrella document, outlining general aspects, but still leaving room for national variations and refinements using more detailed sub-models and methods.

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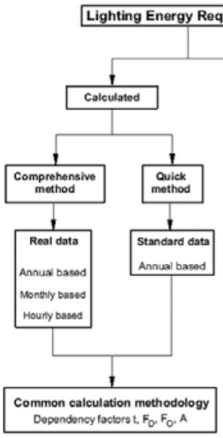

Figure 2: Flow chart illustrating alternative routes to determine energy use.

2 > Principle of the method

Physically, the general calculation approach is based on the integration of the power consumption p(t) of the artificial lighting system over time to obtain the electric lighting energy consumed. For practical applications this relation is simplified by scaling the installed electrical power p_j with an effective operating time t_{eff} as depicted in Figure 3. The effective operating time t_{eff} accounts for effects that reduce the lighting energy consumption by using available daylight or occupancy detection systems. The end result of the calculation procedure is the lighting energy demand of a given building zone or of the whole building, expressed per square meter of floor area, either on a monthly (which is necessary for linking into the overall EPBD and CEN energy balancing scheme) or an annual basis. The annual value is also referred to as LENI (lighting energy numerical indicator).

3 > Artificial Lighting

The standard primarily addresses the assessement of installed electrical power in existing buildings. Detailed measurement procedures are provided.

For new buildings, the standard in its current version does not yet provide an explicit approach that can be used for calculating the installed electrical load. This implies a need for appropriate artificial lighting design in the design phase in order to obtain the installed electrical power, which is required for the overall energy calculation. Simplified estimation methods would be helpful in a future revision of the standard.

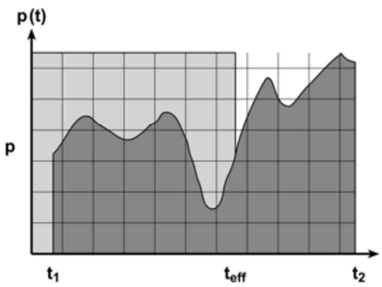

Figure 3: The concept of determining the electric lighting energy consumption by effective operating time t_{eff}.

4 > Daylight

The impact of daylight on lighting energy demand can be determined on a monthly or an annual basis. The CEN standard also explicitly allows a more detailed analysis, i.e. on an hourly level. The methodology requires three steps, depicted in Figure 4:

- For the building area that benefits from daylight, daylight penetration is described as a function of the key construction parameters, as is partially shown in Figure 5: outside obstructions, façade parameters - for vertical facades as well as rooflights – and the room parameters. The daylight factor is used as a classification criterion.
- The façade system is judged by its light transmittance corrected by applying factors allowing for the fenestration, dirt on the glazing and oblique light incidence. In contrast with other methods, sun-shading systems are not covered explicitly.
- Finally, the daylight factor and the façade properties are correlated with the share of the required illuminance in the workplace, the so-called relative luminous exposure. This correlation is a measure of the energy saving potential that can be attributed to daylight. It is illustrated in Figure 6 for the daylight situation at Watford, UK. Data for other sites are also provided. In the CEN approach, the correlation is performed for diffuse illumination only. It is assumed that the direct illumination is filtered by an almost "ideal" sun shading system. This process is used to derive a daylight supply factor which, when considered along with the type of lighting control system can be used to calculate the actual energy saving.

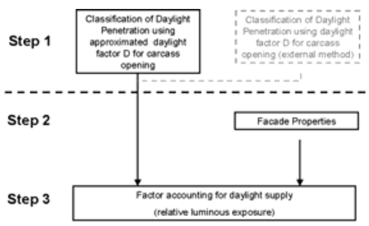

Figure 4: Three step approach for determining the daylight supply.

The impact of the building's site is accounted for by latitude dependent correction factors.

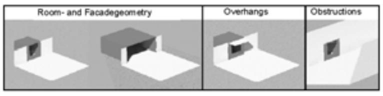

Figure 5: Construction parameters accounted for by the daylight factor.

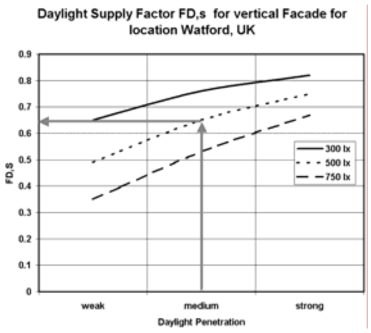

Figure 6: Illustration of the correlation of the daylight penetration with climate and maintenance illuminance level. For a medium daylight penetration into space a daylight supply (energy saving potential of 0,65 (i.e. 65%) can be obtained. This implies, that for an ideal dimmed artificial lighting system only 35 % of the required luminous exposure have to be provided by the artificial lighting system.

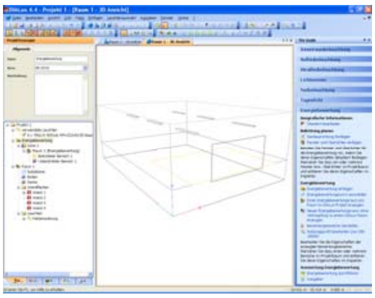

Figure 7: EN 15193 has been integrated into leading professional lighting design software like DIALUX (www.dial.de). Illustration shows the area profiting from daylight, yellow coloured. The rest of the room is not benefiting.

5 > Lighting Controls

The method allows a distinction to be made between occupancy detection and daylight dependent lighting control. Different automatic occupancy detection systems are taken into account. Control systems that respond to daylight are considered and their impact on energy consumption may be calculated.

6 > Benchmarking

For use as a benchmark, the standard calculates the annual lighting energy requirement per square meter for a set of building types. These values are intended to be used as a first estimate of the lighting energy consumption – before a more refined design has been specified in detail. In addition to the building type, the benchmarking system distinguishes between different lighting quality levels, which are directly linked to the assumed value of the power of the installation.

In comparison with measured energy use and also with values obtained by using alternative methods, the benchmark values appear to be uniformly high, so in a revision of the standard the magnitude of these values should be checked.

7 > Software: Bringing the standard into daily design practice

In calculating overall building energy, daily design practice must be supported by appropriate software tools. For calculating the lighting energy demand , some tools do already exist (e.g. DIALUX (*www.dial.de*), exemplified in Figure 7, and Relux (*www.relux.ch*), both available as freeware). Nevertheless, for the moment, no software is yet available for calculating the overall building energy demand according to the set of CEN standards implementing the EPBD.

8 > Conclusion and Outlook

EN 15193 provides a useful umbrella framework, with a calculation method that is both simple and general. More detailed methods can be applied either as recommended in the appendix of EN 15193 or as stipulated at a national level.

Except for the determination of the installed power in new buildings, the standard allows stand-alone calculation, and thus the energy analysis and optimization of lighting installations. It integrates artificial lighting, daylighting and lighting controls.

Further improvement of the standard and enhancement of its usability would be obtained in future versions by including a simple method for determining the installed power, by a re-consideration of the unexpectedly high benchmark values it currently tabulates and by the inclusion of methods for rating sun shading and glare protection systems and optimising them for energy conservation purposes.

9 > References

1. EU-Directive, Energy Performance of Buildings. Directive 2002/91/EG (2002).
2. prEN 15193-1: Energy performance of buildings-Energy requirements for lighting – Part 1: Lighting energy estimation. CEN, Brussels (2005)
3. EN 12464-1: Light and lighting-Light of work places – Part 1: Indoor work places

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