

Estimation of energy requirements for lighting in buildings

All buildings occupied by humans require some form of lighting to ensure that people have visibility to circulate, be able to take part in activities and carry out visual tasks. The required quantity and quality of lighting varies for buildings, activities and visual tasks and for good practice the design conditions are defined in the CEN lighting application standards EN 12464-1 for indoor work places, EN 12193 for sports facilities and EN 1838 for emergency lighting. These lighting conditions can be achieved with electric light or daylight or a combination of the two.

As we now live in 24 hour society almost no buildings can be illuminated by daylight only. Therefore electric lighting has to be installed. In the interest of energy efficiency it is important that the lighting schemes are designed to provide the right light in the right place at the right time. Also important that the electric lights used are energy efficient, conforming to the Ecodesign regulations and are managed by suitable lighting controls system.

Carrying out a comprehensive lighting design (daylight and electric lighting) for new or refurbished buildings will yield both effective and energy efficient lighting solutions that fulfil all the lighting criteria specified in the lighting application standards. The lighting design process will show how much daylight will be available and how much electric lighting is needed and what scheme solutions will satisfy the required lighting conditions during the occupied periods.

The energy required and the energy efficiency (LENI) of the electric lighting scheme can be estimated by using the procedure given in the European standard EN 15193:2007. This standard has been updated and will soon be published as EN 15193-1. This article gives an overview of the new standard.



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The new standard specifies two methods for calculations and one for direct metering of the energy required for lighting. The standard provides the necessary steps, equations and some data required for the evaluation of the amount of energy used for indoor lighting inside buildings. The standard also introduces a new method called “expenditure factor” that evaluates the relative performance of each element in the energy calculation. In the eight Annexes it gives tables with default data, template for entry of local default data and detailed instructions for the calculation of the dependency factors. **Figure 1** shows the process involved in the three methods.

The standard will be supported by a Technical report CEN/TR 15193-2 that not only gives more helpful advice on calculation steps but also provides worked out examples, benchmark LENI values for sample lighting installations, descriptions of integrated lighting controls and a domestic lighting guide.

The role of LENI

The methodology of energy estimation not only provides values for the Lighting Energy Numeric Indicator (LENI) but it will also provide input from lighting contributed energy to the heating and cooling

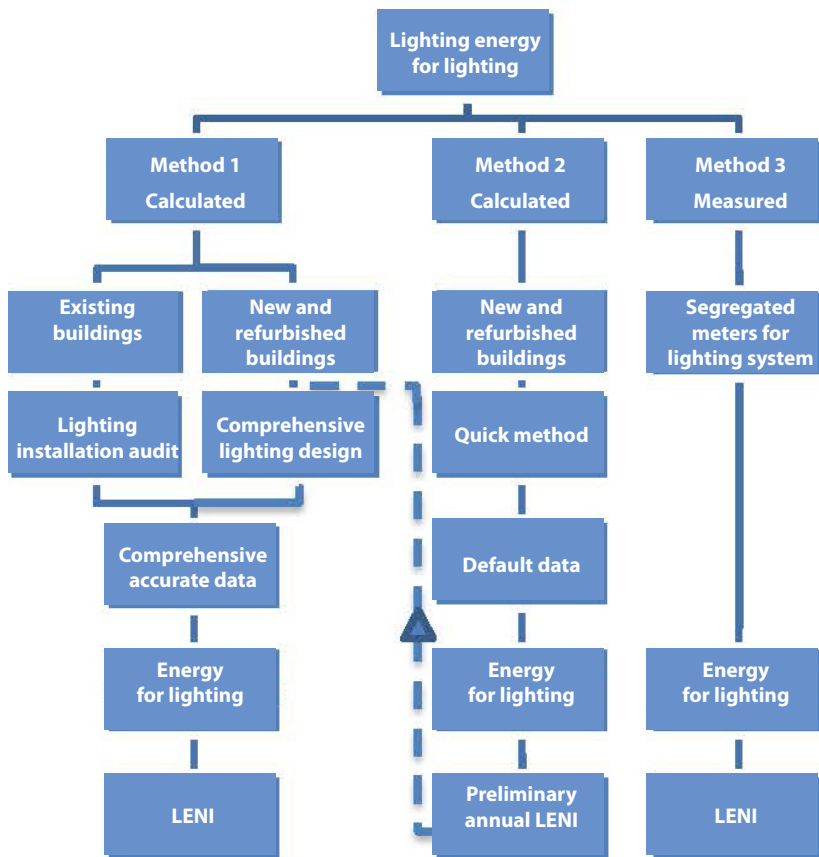


Figure 1. Overview of the flow of the process to determine the required energy for lighting and LENI, the indicator of the energy efficiency of the lighting, in buildings.

load estimations and for use in the energy performance of building certification. LENI is a simple concept and offers a valuable measure for the energy efficiency of lighting in areas or buildings. The measure can be used for comparing the performance of similar areas or building types in the EU. The measure also lends itself to set lighting efficiency ratings or benchmarks for designers for lighting solutions. LENI has been in use since 2007 and several EU member states have adopted it as the tool for setting lighting efficiency measures in buildings.

Application of the new standard

In the new standard methods 1 and 2 may be applied to new, existing or refurbished buildings whilst method 3 is for existing buildings where where the lighting circuit is sufficiently segregated to allow separate metering. The standard deals with fixed general lighting systems and does not cover the design of lighting systems, the planning of lighting installations, the characteristics of lighting equipment (lamps, control gear and luminaires) or the systems used for display lighting, desk lighting and luminaires built into furniture.

Method 1, the preferred route for the energy requirements for lighting over specified time step, follows a comprehensive procedure in which accurate real data on the daylight availability, electric lighting including lighting control performance and occupancy periods are available from the lighting scheme design for all areas and zones of a building type. It will also yields the most accurate value for LENI. Method 1 is the most accurate calculation method and it can also be used for existing building where a comprehensive lighting survey or audit is carried out to establish the installed lighting load.

Method 2 is a simplified quick method that relies substantially on default data provided in the standard

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for activity areas of different buildings for use in the annual estimation of the energy requirement for lighting. Method 2 is suited for use at concept stage of design and will yield preliminary annual energy requirements and LENI. These budget values are used for the initial energy performance certificate in planning applications but will need to be recalculated using method 1 when the lighting design is completed.

Method 3 is by metering the energy used for lighting and will give the most accurate measure of LENI. The metering can also provide regular feedback on the energy used and the effectiveness of the lighting controls.

Energy for lighting calculations

In Methods 1 and 2 the energy requirement for lighting for an area, zone or building is calculated by summing the energy needed for illumination ($W_{L,t}$) and for standby systems ($W_{P,t}$) for a specified time step (t_s) by using the equation

$$W_t = W_{L,t} + W_{P,t} \text{ [kWh / } t_s\text{]}.$$

LENI for the space where A is the useful area under consideration is calculated by the equation

$$W_t / A \text{ [kWh/} t_s \text{ m}^2\text{]}.$$

The energy for illumination ($W_{L,t}$) is given by the summed up installed lighting power load (P_N) and as modified by the lighting controls during the operational time step (t_s) as given by the equation

$$W_{L,t} = \sum \{(P_n \cdot F_c) \cdot F_o [(t_D \cdot F_D) + t_N]\} / 1000 \text{ [kWh / } t_s\text{]}.$$

The lighting controls can respond to daylight availability (F_D daylight dependency factor), occupancy (F_o occupancy dependency factor), overdesign (F_C constant illuminance factor) that compensates for light losses in a maintenance cycle and the day (t_D) and night (t_N) time occupancy periods.

The energy for standby systems ($W_{P,t}$) required during non-lighting periods to provide charging power (P_{em}) for emergency lighting during charge time (t_c) and the lighting activation power (P_{pc}) for lighting controls for the period (t_s) where no electric light during daytime (t_D) or night time (t_N) is used in an area or zone of the building, is calculated by the equation

$$W_{P,t} = \sum \{(P_{pc} \cdot [t_s - (t_D + t_N)]\} + (P_{em} \cdot t_c) / 1000 \text{ [kWh / } t_s\text{]}.$$

Expenditure factors for lighting systems

The standard gives a procedure for the calculation of the expenditure factor or effort factor. This measure gives an indication of the energy efficiency of the chosen lighting solution compared to a reference system. The expenditure factor (e_L) for the lighting system is the ratio of the energy required or used (W_{us}) for the actual lighting to the reference energy (W_{nd}) needed for the lighting as shown by the equation

$$e_L = W_{us} / W_{nd}.$$

It can also be derived by the products of the individual influences as given in the equation

$$e_L = e_{L,C} \cdot e_{L,O} \cdot e_{L,D} \cdot e_{L,ES}.$$

Where

- $e_{L,C}$ is the partial expenditure factor for constant illuminance control
- $e_{L,O}$ is the partial expenditure factor for occupancy dependent lighting control
- $e_{L,D}$ is the partial expenditure factor for daylight dependent lighting control
- $e_{L,ES}$ is the partial expenditure factor for the electric lighting system

The higher the expenditure factor the less efficient is the lighting system. Applying the methodology allows a quick analysis of the energy flows in an electric lighting system, separately for each of its technical components. As specific conventions are required for the energy assessment of lighting systems, such as luminous efficacy and luminous intensity distribution, the absolute values received for the expenditure factor are specific for lighting and cannot be directly compared with other technical building services. The Technical report describes the background and detailed operation of the concept and also gives worked example of expenditure factor for a lighting scheme.

The new standard together with the technical report will provide a comprehensive yet easy way of estimating the energy requirements for new and existing lighting installations. LENI can provide a good measure for the energy efficiency of the installed scheme whilst the expenditure factor can identify the elements that merit further performance improvements. Good lighting is essential for people in all buildings and this light should be provided by the most appropriate and efficacious solutions. ■