

Chapter 12: Proposalstoupgraderecommendations and codes

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12 Proposal to upgrade lighting standards and recommendations

12.1 A difficult trade-off between energy conservation and satisfaction of human needs

The growing concern of energy performance in buildings leads to the search for a “reasonable” optimum in installed lighting power. Because of this, gathering of robust evidence of fundamental minimum requirements in lighting is needed. On one hand, visual requirements related to visual acuity lead to rather high illuminance levels (500 lx to read), and even higher if we consider the population above 60 years of age. On the other hand, general ambient lighting is more related to balance of luminances, absence of glare, and minimum illuminances for displacement or filing documents (minimum illuminance around 100-200 lx).

12.2 The origins of lighting standards and recommendations

The evolution of standards has, at large, followed the development of lighting technologies, cost of lighting and the increased scientific understanding of vision. The lighting recommendations have dealt with the optimum visual performance, appropriate light distribution, glare reduction, color rendering, in relation to the available technology. Targets for the above mentioned values were defined at performance levels, achievable at reasonable costs of equipment and energy. In the second half of the 20th century, the availability of powerful and inexpensive light sources such as tubular triphosphor fluorescent lamps led to an increase in the recommended illuminance levels. Later, the development of VDU workstations led to increased demands for glare control and avoidance of light reflection from the screens.

At the end of the 20th century, several research results suggested a more global approach for interior lighting design. For example:

- More concern was given to the satisfaction of occupants over long term, and their general rating of the indoor environment.
- Relation of human to light was addressed in the physiological side, with the discovery of a novel light receptor in the eye, related to the non-visual effects of light, and managing our circadian rhythms.
- Several studies identified the potential for energy conservation through higher use of daylight, and development of energy efficient lighting design and control strategies.
- The contribution of electric lighting to the overall energy use of buildings was identified, along with its impact on requirements on air conditioning, cooling and heating.
- New technologies were proposed, leading to a potential increase in the performance of light sources, luminaires and systems. A great leap forward was taken by the lighting industry in laying the foundation for developments of new light sources like high pressure sodium lamps, metal halide lamps, improved phosphors for fluorescent lamps, etc.
- A better understanding of the environmental impacts of lighting components led to the progressive development of pollutant reduction and increased activities for recycling.
- The development in the solid-state lighting technology has brought new light sources (LEDs) in the market at breakneck speed. By today, LEDs are a viable option also for general lighting and soon it will be competing in energy-efficiency with the traditional light sources.

12.3 Challenges for new lighting standards and recommendations

The difference between the lighting standards and recommendations in different countries has been attributed to the economical context and the geographical zone of the country. The differences are related to the living standard, technological and economical capacity and also to the influence of specific research or institutional organizations. A major future development of lighting recommendations is that they should address many other topics beyond the visual specifications associated to the satisfaction of specific activities. Recent research results suggest that the following considerations are to be included in future indoor lighting recommendations:

- Minimum illuminance on work plane in office lighting. A value of 500 lx is proposed by CEN Norm EN 12464-1 (item 3.2 and 3.4). The current recommendations concern mainly the level of illuminances on the desk area, but it should be remembered that what people perceive are luminances, i.e. light reflected from the surfaces. Thus, it should be kept in mind that the required minimum illuminance is also related to the values of the luminances in the visual field. Therefore, discussions about the 500 lx minimum value should integrate a more luminance based approach. Also, the individual and age-related differences in the required light levels should be considered, for example aged workers may need more light than 20-year old workers.
- Since reading and writing is performed on a small part of the desk, and since a computer screen is now the standard of a workplace, it is suggested that the recommended illuminance of 500 lx should be achieved only on the reading and writing area of the desk (see Figure 12-1). This is being discussed within CEN TC 169 WG2.

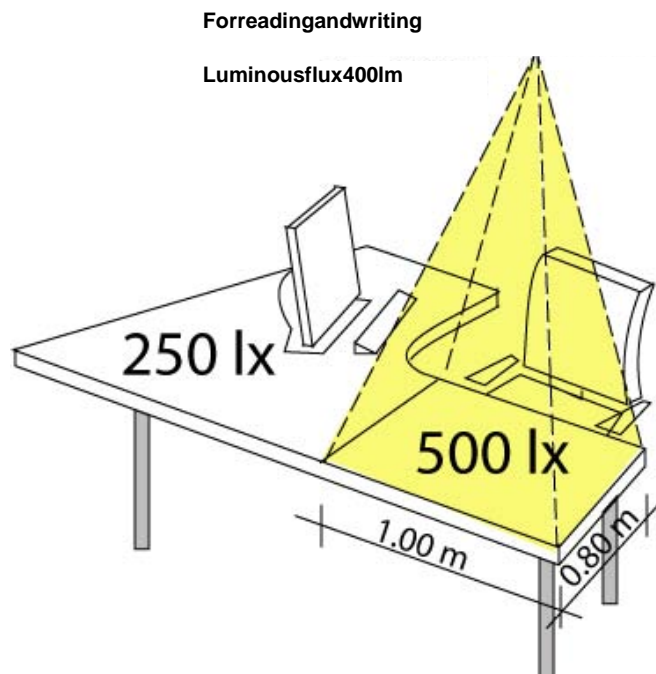
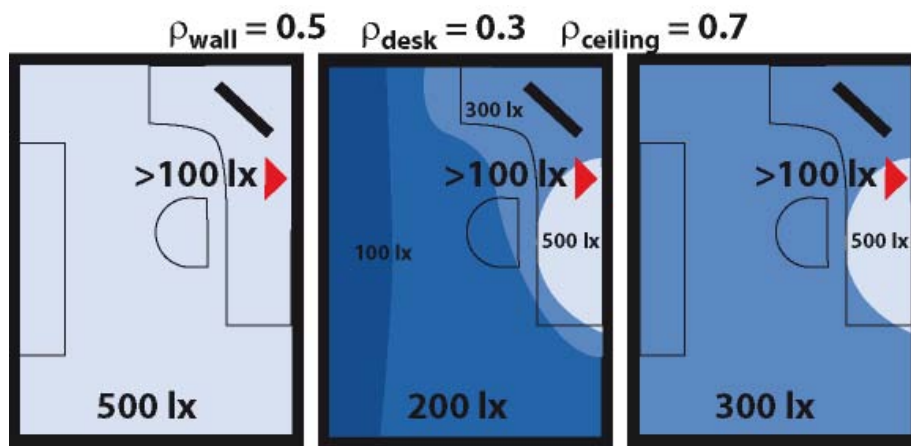


Figure 12-1. Possible distribution of illuminances on workplane for optimal visual performance and energy efficiency.

- The rest of the work plane would then require a lower illuminance. Recommendations suggest not to go to a value less than about two third of the values on the task (EN 12464-1 proposes 300 lx for workplaces). Discussions about minimum illuminance values for the rest of the room

- for (not reading) would be useful.
- Uniformity of illuminance. According to CEN Norm EN 12464-1 minimum threshold of 0.7 is required on the task, and 0.5 for the immediate surroundings. Not much is said for the rest of the room. Tests performed on observers demonstrate that they responded positively to various kinds of modulation of the illuminance distribution. Variations of illuminances in spaces, in ratio of 1 to 2 or 1 to 3 appear appropriate, as long as they are correctly managed. Discussions on the evolution of recommendations require evidence of the acceptable limits on this aspect.
 - Indoor lighting design is based largely on providing more or less uniform levels of illuminances in the room, while the perception of the luminous environment is related mainly to light reflected from surfaces i.e. luminances. Thus innovative lighting design methods could be introduced which give a high priority to the quality of the luminous environment as our eyes perceive it. The possible obstacles and constraints that are set by the current regulations for horizontal illumination levels should be identified, and ways for designing and implementing more innovative lighting solutions should be sought. Figure 12-2 presents three different lighting installations. Configuration 1 is without task lighting and configurations 2 and 3 with task lighting. The daylight contribution is different in different cases. Table 12-1 presents the installations in detail. Both the electrical lighting design (general/task lighting) and the use of daylight have a major impact on lighting quality and energy efficiency.



Configuration 1

Configuration 2 Configuration 3

Figure 12-2. Three different possible configurations for lighting with vertical the same illuminance on task (500 lx) but various illuminances in the room (200, 300 and 500 lx). Minimum illuminance is 100 lx in all cases.

- Glare control. Recommendations include specifications on glare control, but not on overhead glare. Luminaires with high luminance light sources such as CFL, T5 or spot lamps (halogen, LEDs) have been found to be uncomfortable if the sources are visible, even if they are located above the head of the observers (Figure 12-3) recommendations need to be updated to propose more restrictions of luminances and higher angles of observation.

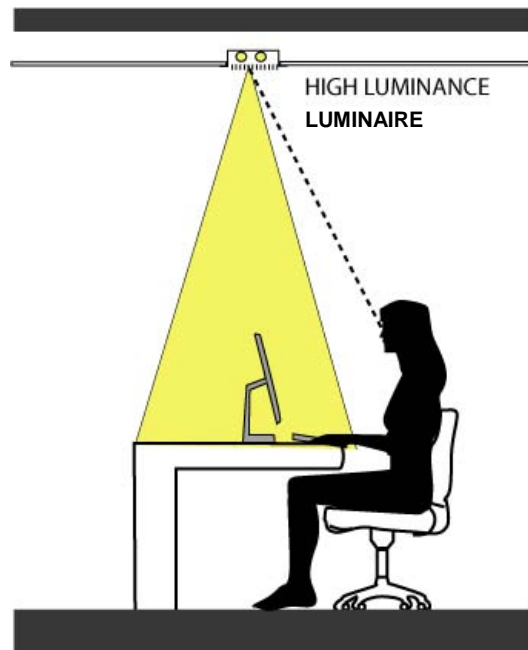


Figure 12-3. Overhead glare issues: discomfort glare occurs even when the luminaire is just above the occupant, if luminaire luminance is high (above 14000 cd/m^2). Such can be the case with unshaded CFLs, LEDs, halogens and T5 fluorescent lamps.

- Reduction of the size of light sources (compact HID lamps, LEDs) may lead to increased risk of glare. Standards and recommendations should be adapted accordingly.
- Luminance distribution. Balance of luminances in the field of view is expressed in the recommendations in order to reduce fatigue and eye stress. Recent findings suggest that luminances of vertical surfaces facing the occupants also play a role in visual stimulation and alertness (see CIE Div 3 TC work: Luminance Based Lighting Design).
- The quality of light spectra is required with a minimum Color Rendering Index CRI of 80. The light sources typically used in office lighting have good CRI. The CIE general CRI has its limitations. The shortcomings of the CRI may become evident when applied to LED light sources due to their peaked spectra. The CIE (CIE 2007) recommends the development of a new color rendering index (or a set of new color rendering indices), which should be applicable to all types of light sources including white LEDs.
- Daylighting is suggested, but lighting recommendations do not specify recommended values of daylight factors or other parameters. This is a field where practical metrics could be developed, and mentioned in recommendations.
- Glare from windows is not addressed, and there could be recommendations for sun shading systems to prevent glare.

Table12-1. Comparisonoftheenergyperformancesofthethree lightingconfigurationsinFigure12-2.

Feature	Configuration1	Configuration2	Configuration3
Powerdensityofceilingluminaire	11W/m ²	4.4W/m ²	6.6W/m ²
Powerdensityoftaskfocusedlighting		1.7W/m ²	1.7W/m ²
Roomarea	12m ²	12m ²	12m ²
Annualburninghoursofceilingluminaire	2000h	2000h	2000h
Annualburninghoursoftaskfocusedlighting		1600 h	1600h
Energyconsumptionwithoutdaylight	264kWh/a	138kWh/a	191kWh/a
Energyconsumptionwithdaylight(30%)	185kWh/a		
Energyconsumptionwithdaylight(70%)		41kWh/a	
Energyconsumptionwithdaylight(50%)			95kWh/a
Energydensitywithoutdaylight	22kWh/m ² .a	11.5kWh/m ² .a	15.9kWh/m ² .a
Energydensitywithdaylight	15.4kWh/m ² .a	3.41kWh/m ² .a	7.91kWh/m ² .a

