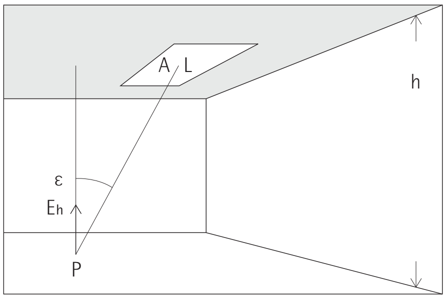
$$E_h = \frac{L \cdot A}{h^2} \cdot \cos^4 \varepsilon$$

[E] = lx

[l] = cd/m²

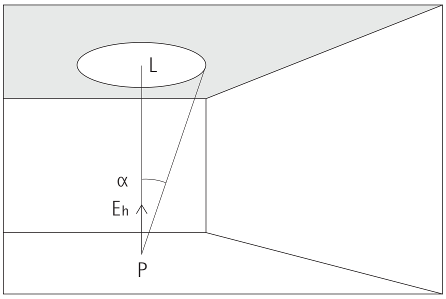
[h] = m

[A] = m²



Horizontal illuminance E_h at point P, produced by luminous surface A of luminance L at angle ε.

$$E_h = \pi \cdot L \cdot \sin^2 \alpha$$

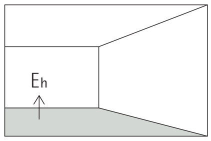


Horizontal illuminance E_h at point P, produced by a circular luminous surface of luminance L, whereby the surface extends to an angle 2 α.

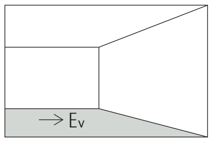
Calculating illuminances from the luminance of flat light sources.

$$E_h = \pi \cdot L$$

$$E_v = \frac{\pi}{2} \cdot L$$



Horizontal illuminance E_h, produced by luminance L from one half of the space.



Vertical illumnancee E_v, produced by luminance L from one half of the space.

3.3.6.4 Lighting costs

When calculating the costs for a lighting installation it is necessary to differentiate between the fixed costs and the variable costs. The fixed costs do not apply to the operating time of the lighting installation, they comprise the amotised costs for the luminaires, for their installation and cleaning. The variable costs are dependent on the operating time. They comprise costs for energy, material and wages for staff carrying out lamp replacement. On the basis of these values it is possible to calculate the different qualities of a lighting installation.

The annual costs of a lighting installation are of particular interest. It is often advisable to compare the economic efficiency of different lamp types in the planning phase. This data can be calculated either as annual costs or as costs for the production of a specific quantity of light. The pay-back time is important in both completely new projects and refurbishment projects, that is to say the period of time within which the operating costs that have been saved can be set off against the investment costs for the new installation.

Formula for calculating the costs of a lighting installation K from the fixed costs K' and the annual operating costs K".

$$K = K' + K''$$

$$K' = n\,(p \cdot K_1 + R)$$

$$K'' = n \cdot t_B\,\left(a \cdot P + \frac{K_2}{t_{La}}\right)$$

$$K = n\left[p \cdot K_1 + R + t_B\left(a \cdot P + \frac{K_2}{t_{La}}\right)\right]$$

Formula for calculating the pay-back time t of a new installation.

$$t = \frac{K_I\,(\text{new})}{K''\,(\text{old}) - K''\,(\text{new})}$$

Comparison of the pay-back time t of two new installations, whereby installation B has higher investment costs and lower operating costs.

$$t = \frac{K_I\,(B) - K_I\,(A)}{K''\,(A) - K''\,(B)}$$

a (DM/kWh)	Energy costs
K (DM/a)	Annual costs for a lighting installation
K' (DM/a)	Fixed annual costs
K" (DM/a)	Annual operating costs
K_1 (DM)	Costs per luminaire incl. mounting
K_2 (DM)	Costs per lamp incl. lamp replacement
K_I (DM)	Investment costs ($n \cdot K_1$)

n	Number of luminaires
p (1/a)	Interest payments for the installation (0.1–0.15)
P (kW)	Wattage per luminaire
R (DM/a)	Annual cleaning costs per luminaire
t (a)	Pay-back time
t_B (h)	Annual operating time
t_{La} (h)	Service life of a lamp

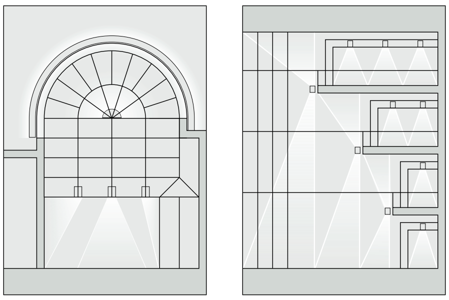
3.3.7 Simulation and presentation

Visual presentations of lighting installations and the effects they produce in the architectural space play a significant part in lighting design. There is a wide range of possibilities for presenting a lighting concept ranging from technically oriented ceiling plans to graphic illustrations of varying complexity to computer-aided renderings and three-dimensional architectural models or models of the lighting installation.

The aim of such presentations is to provide information. This may be by way of the technical qualities of a lighting installation, the spatial design or the lighting effects in the luminous environment. Computer-aided renderings and models can also be used to simulate the lighting effects of a planned installation and to gain new information.

One of the first forms of presentation of lighting installations are technical drawings and diagrams. The reflected ceiling plan is the most important. It provides exact information about the type and arrangement of luminaires. This documentation can be supplemented by illuminance values entered on the ceiling plan or isolux diagrams, or additional drawings showing different perspectives of the luminous environment. All these help to illustrate the lighting layout and its effect in the space.

Graphic material of this kind allows the lighting designer to derive technical information about the installation and gain a realistic impression of the lighting effects produced. This cannot be expected of other persons involved in the planning process who are not so experienced in technical or lighting matters. It is therefore advisable not always to place too much reliance on technical documentation when presenting a lighting concept.


Graphic presentation of a lighting concept.

To illustrate a lighting concept it is therefore better to opt for presentation material that reflects the architecture and the lighting installation and the lighting effects that can be expected. From the point of view of drawings, simple sketches may suffice. The larger the project, the more detailed the graphic presentation will have to be to show the differentiated lighting effects in the luminous environment.

With the exception of drawings that are based on existing installations or simulations, even the more complex forms of representation will reproduce lighting effects in the form of diagrams, which do not demonstrate the complexity of the actual lighting effects. This need not necessarily be a disadvantage; when explaining an overall concept a simple yet effective sketch can illustrate the intended lighting effects much better than an apparently realistic representation with artificially staggered luminance levels. In most cases a drawing is an economical way of presenting an idea, is adaptable and can be prepared quickly.

Graphically, lighting effects can best be illustrated in the form of beams of light, which either appear as an outline of the beam, as a coloured area or in a shade of grey that will allow them to stand out against a background colour. If luminance patterns are also to be represented, this can be produced using special shading techniques or by free-hand drawings using pencil or chalks. If more contrast is required in the drawing to be able to represent a greater range of luminances, this can be produced using hand-drawn white lines against a grey shaded background. For greater differentiation a method using backlit transparent paper, a collage of foils with different transmittance qualities provides an extremely broad scale of luminances from black to the luminance of the lightest source applied.

Besides drawings, it is also possible to use computer programs to illustrate lighting installations and the effects produced. Lighting calculations programs generally comprise simple spatial representations with different illuminance levels represented by black/white shading. That is to say, besides producing lighting data in tables and diagrams computer programs are also able to give a rough visual impression of the lighting concept. Creating more complex computer graphics with a more differentiated representation of luminances, colour and the furnishings in the luminous environment requires advanced hardware and software.

Similar to a drawing, computer graphics only provide a simplified picture of the actual lighting effects; grading luminances too strictly will often give rise to a rigid, artificial impression. In contrast to drawings, computer graphics do not produce a subjective idea of the lighting effects that can be expected, but are based on complex calculations; they are therefore not only a presentation aid, but also an effective means of simulation.

Although it does take some time to enter the data concerning the architecture, lighting installation and possibly furniture, this may be justified because it does allow more flexibility to try out different luminaire types and lighting concepts. It is frequently advisable to do without detailed computer graphics to illustrate the effect of the light in a given space and to make drawings based on the lighting data produced by the computer calculations instead.