

# licht.wissen 14

Ideas for Good Home Lighting



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# Editorial

One of the most important things in life is having a place where we really feel at home. It makes no difference whether it we own it or rent it or whether it is an apartment or a house: what matters is the sense of security and wellbeing we feel within its walls. The right lighting concept plays a crucial role here.

Science defines light as the band of electromagnetic radiation that is perceptible by the human eye. The designer sees it as a tool offering innumerable possibilities for crafting living space to suit personal needs and preferences. Our aim in publishing this licht.wissen 14 is to highlight those possibilities and to provide a guide that will help you translate them successfully into good lighting – because correct lighting not only promotes a sense of wellbeing; it is also good for health.

What the sun does outdoors needs to be performed indoors by artificial lighting. In nature, the soft diffuse light of the sky combines with the dynamic, directional light of the sun to present a spectacular ever-changing show of light and shadow. Magical moments are created, for example, when sunbeams dance in the forest or when shafts of light suddenly burst through the clouds on an overcast day. In the home, background brightness is provided by general room lighting, while lighting accents are set by supplementary zone lighting. A balanced lighting design is a prime requirement for an optimal room atmosphere, which has positive physiological and psychological impacts both above and below the conscious threshold.

This booklet contains a range of design ideas and tips for lighting in the various parts of the home. It also covers aspects such as quality criteria, standards and regulations. If you require more in-depth information on any of the topics featured here, we recommend that you check out the knowledge database at [www.licht.de](http://www.licht.de), which bundles impartial expertise from more than 120 licht.de members. licht.de (formerly Fördergemeinschaft Gutes Licht looks back more than 30 years as your competent contact for all questions relating to light and lighting.

From entrance to bedroom, bathroom to nursery, living room to kitchen – every room in the home needs a lighting concept that is tailored to the function or functions it performs. While reading this booklet, simply imagine walking through the rooms of your planned or present home, bringing each one to life with good lighting.

In that spirit, on behalf of licht.de, I wish you lots of fun and lots of good ideas for better lighting in your home.

Dipl. Designer Klaus Liese

**[Front cover]** Living room with different lighting zones that can be tailored to individual requirements.

**[01]** Lighting in and around the house has an impact after dark. Illuminated plants and underwater lights provide the finishing touches for an enchanting lighting atmosphere.

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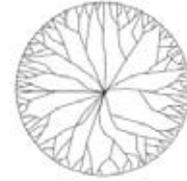
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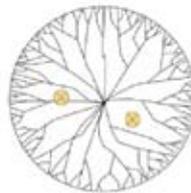
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Spots for illuminating plants



Lighting Specials:

Detailed professional information on important issues relating to good design, lighting control, safety, energy efficiency and lamps.

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# Entrance lighting

The entrance to a home merits special attention where lighting is concerned. It is the first thing a visitor sees. So it is important to select bright and cheerful – but also practical – lighting that reflects the style and personality of the occupants.

**[02-04]** Outdoor lighting should suit the style of the house and underline the architecture. Luminaires should be designed and positioned so that no one is dazzled by their light

**[08]** Recessed ground luminaires lead guests to the house and cast the entrance in a special light. In the driveway, recessed ground luminaires with safety glass enclosures for loads up to 3,000 kg and with a high degree of protection (IP 65 or IP 67) are a suitable option.

Good exterior lighting is not just decoration; it also helps provide security for residents and guests. Driveway and entrance lighting is the calling card of any home. It indicates the safe route to front door, garage or carport. It also extends a welcome to guests and facilitates the identification of visitors.

An illuminated house number ensures that not only guests but also taxi drivers, delivery services and, in an emergency, medics find the house quickly.

To ensure easy orientation, the route to the front door needs to be sufficiently bright. Where there are stairs or steps on it, safety is ensured by supplementary plinth, bollard or orientation lights.

It is important that there should be a well illuminated area at the front door. This

ensures that key and keyhole can easily be found and names beside doorbells are clearly legible.

Lighting all around the building offers comfort and security. It also provides protection against uninvited guests. Motion detectors allow no one to approach under cover of darkness.

Photoelectric lighting controllers permit comfortable and economical lighting. Suitably compatible energy-saving lamps are recommended here.

Wall luminaires and downlights set in canopies or overhanging roofs can strikingly underline the architecture of a house. Recessed ground luminaires cast buildings and surrounding vegetation in a dramatic light.

## Lighting tips: House entrance

**Front door lighting [03-05]** Wall luminaires or downlights recessed in canopies are particularly suitable for front door lighting. To ensure that they withstand all weathers, only quality luminaires with rating plate and mark of conformity should be used. IP44 (protection against solid bodies larger than 1 mm and splashwater) is a minimum requirement for outdoor applications.

**Step and obstacle lighting [06]** Bright lighting for obstacles and steps makes for safety. Appropriate lighting options include step lights and bollard/post-top luminaires.

**House number lighting [07]** Permanently illuminated, sufficiently large house numbers are needed to ensure that visitors find the house quickly. To ensure that a house number can be read easily from a distance, self-illuminating numerals should be at least 10 cm and externally illuminated numerals at least 20 cm high.





# Hall and stairway lighting

Bright, good lighting is essential for the most important circulation areas of a house or apartment. The prime requirement in a hallway is safety and sufficient light at the coatstand and mirror. However, lighting should also set accents and ensure that a guest's first impression of the home is a positive one.

Whether visitors are going to feel at home in a house is decided the moment they step through the door. In many cases, hallways have no window. So bright, invigorating lighting is also required there during the day.

light before stepping outside. Hallways look larger and more attractive where room lighting bounces off ceiling and walls. This is best realised with ceiling or wall luminaires that emit as much light as possible upwards or sideways.

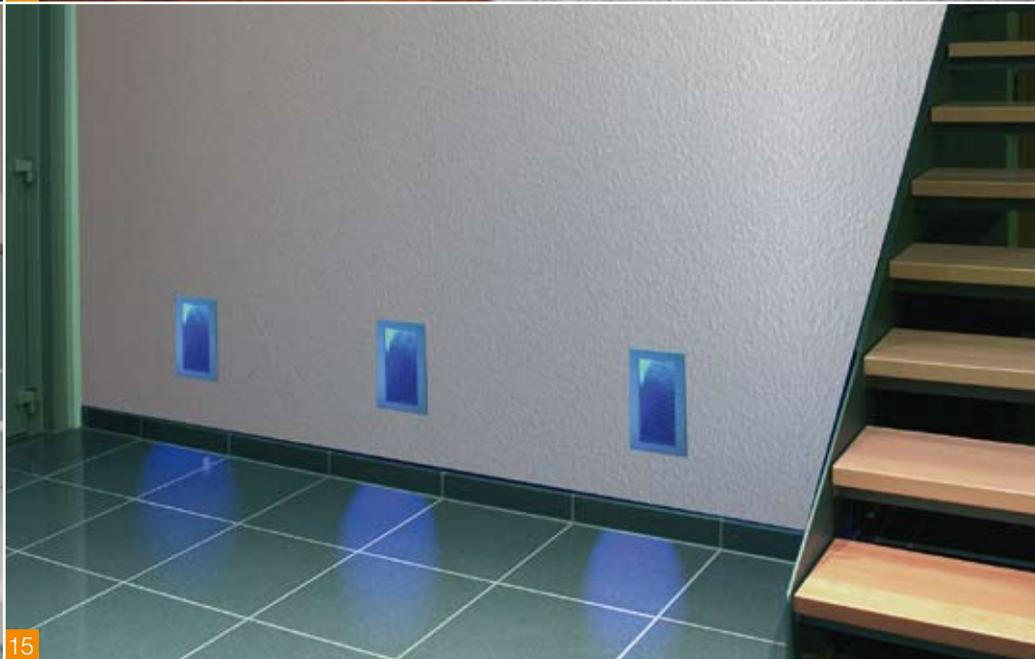
[09] Special architectural features can be emphasized to very good effect with a track system. It also offers lots of opportunities to highlight different functional zones.

[10] Step lights make staircases safer and provide eye-catching illumination. They also emphasize and positively accentuate the materiality of the stairs.

In addition to the general room lighting required for background brightness, spots can be effectively used to highlight furniture and pictures. Mood lights on a sideboard or chest of drawers can help create an inviting atmosphere. Attention should also be paid to good mirror lighting. This enables anyone leaving the house to run a quick eye over their clothing in good

Track systems – which allow a number of luminaires to be deployed regardless of where the ceiling outlet is located – are a good solution for a hallway. Combining room lighting with zone lighting, they make for a balanced but dynamic lighting design.





## Safety in the stairway

Sadly, staircases are a frequent scene of accidents. The cause, in many cases, is poor lighting: either it is not bright enough or the light of incorrectly positioned luminaires dazzles or generates confusing shadows that can lead to errors of judgement with serious consequences.

Most accidents happen on the way down stairs. So it is particularly important that lighting should make the individual treads clearly discernible from above. Stair treads are well lit when each individual tread casts a short, soft shadow

that distinguishes it from the next. This is best achieved with a luminaire installed at the top landing or by step lights that are integrated in the wall and illuminate each step separately. Staircase and hall area should also be uniformly and brightly illuminated by the general lighting.

Wall luminaires make for a more informal lighting atmosphere and set positive accents. Care must be taken, however, to ensure that the light does not dazzle anyone walking up or down the stairs and does not give rise to confusing cast shadows.

[11-14] The optimal complement for general lighting, wall luminaires set design accents in the room.

[14] The eye tends to be drawn to bright areas. Where pictures or objects are illuminated, they attract attention and help make for agreeable and interesting hallway lighting.

[15-16] Recessed wall luminaires and step lights with LED or halogen lamps make for added safety. However, provision needs to be made for the necessary power outlets at an early construction stage.



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## Lighting tips: Hall and stairway

**Mirror lighting [17]** The best way to illuminate a person at a mirror is to position luminaires with warm-white lamps at the right and left of the mirror for shadow-free lighting.

**Hall stand lighting [18]** It is advisable to install supplementary luminaires to ensure uniform illumination of a cupboard or coat stand.

**Important note:** luminaires recessed in or mounted on wood surfaces need to display the fire protection symbol "F", "M" or "MM" and should be VDE, ENEC or GS certified.

**Avoid glare on stairs** The lamps in wall luminaires for stairways need to be shielded from above and below and definitely must not cause glare.

# Lighting Special: Lighting design and planning

A single luminaire is not enough to provide perfect lighting for a room. Good lighting design depends on a sensitive composition of diverse light sources at different locations. This creates atmosphere and defines different zones for reading, work or relaxation.

At the heart of a successful lighting design is knowledge of the different functions of lighting.

In nature, the soft diffuse light of the sky combines with the dynamic, directional light of the sun to present a spectacular ever-changing show of light and shadow. Magical moments are created, for example, when sunbeams dance in the forest or shafts of light suddenly burst through the clouds on an overcast day.

In the home, background illumination is provided by general room lighting, while individual areas are visually accentuated by supplementary lighting for specific zones. These two components are essential for lighting that is not just functional but also promotes a sense of wellbeing and is good for health.

differences in brightness, it facilitates adaptation between different lighting zones and thus helps prevent early visual fatigue.

Without general room lighting – e.g. in a living room in which the only light is provided by a reading light beside the sofa – we find our surroundings dark and disturbing. Balanced room lighting creates a comfortable atmosphere and promotes a sense of wellbeing.

## Zone lighting [21]

Zone lighting provides light where it is needed for specific activities, such as reading, eating, working, studying images. At the same time, it sets stimulating lighting accents that are as important for harmony in the room as uniform general room lighting.



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This accentuating light is provided by spots directed downwards or at a wall. The more flexible the positioning of the luminaire, the better the light can be directed to where it is needed. Where a dining table is illuminated by general room lighting alone, the atmosphere tends to feel sterile. Zone lighting underlines the cosy intimacy of family mealtimes.

## Mood lighting [22]

Mood lighting creates a special atmosphere. It emits light but provides little illumination. Instead, it conjures up comfort, romance, fascination, passion. Its sole purpose is to soothe heart and soul.

Room and zone lighting is supplemented by mood lighting. This is not primarily for illumination; like a fire, it acts as an eye-catching design feature and adds a special note to the atmosphere of the home.

## Room lighting [20]

Room lighting is general, background lighting. It spreads illumination evenly throughout the room.



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Room lighting is realised with light directed up towards the ceiling or with luminaires that radiate light uniformly in all directions. This provides the background illumination needed for orientation. Reducing marked

[19] Orientation lights set into the floor, e.g. in a hallway or stairwell, give walls or individual elements a sculptural, almost architectural quality. LEDs are particularly suitable for this because of their small dimensions and long life.



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Mood lighting is most effective in the evening, when the surroundings are dark. The only important thing is that it should not be too bright; this is essential for a relaxing atmosphere. So mood lights should glow rather than shine. They can be positioned wherever they will have an impact, e.g. on a windowsill, dresser, shelf or the floor.

#### Electrics – planning ahead

In a new building, early electrical planning is the key to good lighting design. As a matter of principle, it is better to plan too many wall or ceiling outlets than too few. If a room is rearranged later or put to a different use, the lighting can then still be flexibly adapted to suit the new situation.

#### Mounting options

Most residential interiors have plastered concrete ceilings with or without recessed ceiling outlet boxes. These boxes offer the advantage of a larger connection compartment, in which small transformers, ballasts or even recessed luminaires can be accommodated. In the case of luminaires with a small ceiling base, one disadvantage may be found if the mounting hole spacing of the luminaire differs from that of the outlet box or if the luminaire base is too small to cover the cavity.

Where power outlets are not available at the right place, track or wire systems can help. Supplied with electricity at any point, they bridge the gap to where the light is needed. For example, they are an elegant solution for providing light over a dining table where there is no power outlet available. They eliminate the need for an extension cord looping across the room. Some manufacturers also offer cable ducts specially designed to suit luminaires. Where ceilings are suspended or walls

dry-lined, power outlets are easier to deploy than in concrete ceilings. Even here, however, early light source planning is still the better option. The cavity available offers lots of possibilities for lighting design. For one thing, it can be used to accommodate transformers or ballasts; for another, it permits the use of recessed spots or miniature plug-in lights.

#### Lighting plan

A lighting plan is essential for precise, sophisticated planning of home lighting installations. It should be drawn to scale, define the lighting characteristics required in the room and show furnishings and functional zones. The types and numbers of all luminaires should be identified and their assignment to furniture and electrical circuits indicated. The lighting plan can also show general installation requirements for switches, dimmers, sockets or remote controls (see also page 16).

Specialist lighting retailers and lighting or electrical designers can provide a very useful service here based on modern lighting design and calculation software.

#### Lighting level and glare

Lighting level is an important variable for good vision. Older people need considerably more light than young people because visual acuity decreases with age. On average, a 60-year-old requires twice as high much illuminance (lux) as a child or teenager. This should be taken into account in any lighting design for a dwelling for older people.

Glare is generally caused by the presence of highly luminant surfaces in the field of vision and comparatively weak ambient lighting. Visual performance is impaired and prolonged exposure may result in fatigue, stress and poor concentration.

#### Lamp or light?

The words lamp and light are often confused. Lights are what the industry today calls luminaires but they are frequently referred to in common parlance as “lamps”. A lamp is actually only the light source,

i.e. the fitment that emits light inside a luminaire. Strictly speaking, any reference to a lamp should really be a reference to a “light bulb”.

#### Basic lighting variables

**Luminous flux**, measured in lumen (lm), is the power or quantity of light emitted by a lamp.

**Luminous intensity**, measured in candela (cd), is the amount of luminous flux radiating in a particular direction.

**Luminance**, measured in candela per square metre (cd/m<sup>2</sup>), is the brightness of a surface as perceived by the human eye and is highly dependent on its colour, structure and reflectance.

**Illuminance**, measured in lux (lx), is the luminous flux falling on a given surface.

#### Light colour

Light colour is the intrinsic colour of the light emitted by an artificial light source. It is measured in degrees Kelvin (K). As a general rule, light colours are divided into three groups: warm white (below 3,300 K), neutral white (3,300-5,300 K) and daylight white (above 5,300 K).

#### Colour rendering

Colour rendering determines how naturally we see colours under the light of an artificial lamp. The yardstick used to measure it is the colour rendering index  $R_a$ . Under the light of a lamp with a  $R_a$  rating of 100 (optimal), all colours look natural. Halogen lamps have the best  $R_a$  index (100), fluorescent lamps and energy-saving lamps are normally in the region of  $R_a = 80-90$ .

Colour rendering properties range from  $R_a 20 - R_a 100$  and depend crucially on the quality of the light source.



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# Living room lighting

Reading, chatting, watching TV, playing games... no room in the home is used for as many different activities as the living room. So it is all the more important that lighting should be variable and designed to cater to different moods and requirements. A single luminaire in the middle of the ceiling is not enough.

Lighting is crucial for the atmosphere of a room. Harmonious lighting provides good visual conditions and creates a sense of homeliness.

Given the multifunctional nature of a living room, the light sources in it need to be flexible to meet diverse requirements. The central meeting-point in a living room is often the seating group. In this area, lighting should be positioned to suit personal needs.

## Decentralised luminaire arrangement

To enable the specific requirements of the various zones of a living room to be met, a "decentralised" arrangement of different luminaires is recommended. This zone lighting is combined with indirect room lighting that illuminates the ceiling.

For those who prefer even cosier surroundings, the atmosphere can be further enhanced by mood lights.

## General lighting for the living room

The general lighting in a living room should provide the background illuminance required – preferably with dimming control – and deliver indirect, diffuse light that subtly supports the accent lighting. Helping to reduce marked lighting contrasts in the room, it guards against visual fatigue. Wide-angled and general-diffuse wall, ceiling or standalone luminaires offer appropriate lighting solutions.

In museums or hotels, luminous ceilings or cove luminaires (see lighting tip) are often used for indirect lighting. This type of lighting can also enhance a private living room.

[23] Ceiling spots set accents on the wall and make the room look larger.

[24,26] Standalone luminaires beside the sofa provide light for reading and strike a homely note in the room. To enable the lighting to cater to different moods, it should be dimmable.



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## Lighting tip: Indirect room lighting

**Cove lighting [25]:** Coving is the curving transition between wall and ceiling. Luminaires installed here deliver an indirect, diffuse light. This creates the impression that the ceiling is floating in the air. To achieve uniform light distribution with no dark zones, coving is fitted with linear fluorescent lamps overlapping at the ends or with LEDs. For rooms without coving, luminaires are available with housings which form the coving themselves.



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Luminous ceilings bathe a room in diffuse light and create the impression of a kind of courtyard with open sky overhead. As an alternative for the home, the market offers individual large-area luminaires, which create a similar effect. With RGB-controlled LEDs or fluorescent lamps, there is also the possibility of introducing coloured or colour-changing light.

### Controls and switches

Intelligent positioning of control elements, such as switches, is crucial for ensuring that correct lighting is quickly, flexibly and easily accessible. They should always be located where they are needed: 1) at the side of the door and 2) in the zone in which the luminaire is used, e.g. at the sofa, in the work corner or at the TV set.

[27] Clip-on luminaires can cast shelves or mirrors in a dramatic light and draw attention to interesting details.

[28] Wall luminaires set accents and create decorative patterns of reflected light on the wall.

[29] A variety of light sources enables lighting levels in the kitchen, dining table and lounge area to be adjusted as required.

[31] A high-intensity uplight provides soft indirect room lighting and makes for good background illuminance.

### Accent and zone lighting for the living room

Zone lighting is provided by free-standing, table or pendant luminaires, e.g. over the coffee table. The brighter lighting zones thus produced lend structure to the room and enliven the atmosphere.

The general rule is: to optimise the impact of lighting accents, it is important to ensure that they stand out clearly from the general lighting.

But how can switches and other control elements be positioned where they are needed? That is very easy: thanks to modern wireless technology they can be glued or screwed in place at any point in the room without the need for cabling. For maximum flexibility, a mobile remote control system can be added. Lights can then be conveniently operated without getting up, e.g. from reading in an armchair or working at a table.





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## Lighting tip: Television

TV lighting [30]: At and around the television set, lighting should be variable. For reading or for working at a PC, the area around the screen should be illuminated by low-luminance diffuse light. This reduces the brightness contrast between screen and background and prevents early fatigue. Wall or table luminaires providing diffuse light behind or beside the television set create a relaxing, agreeable lighting atmosphere. There are also TV sets on the market with integrated background lighting.

Important note: To rule out annoying reflections, care should be taken to ensure that light, e.g. from ceiling spots, is not directed at the screen.



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## Reading light

Any part of a living room used for reading has special lighting requirements. First of all, directional light is important for illuminating the reading area; secondly, attention needs to be paid to the ambient lighting. It is not advisable to bathe the book in bright light and leave the background in darkness. This would present the eye with a constant need to compensate for marked differences in brightness. Which invariably results in early visual fatigue.

Good background illuminance in the room – and thus comfortable reading light - is achieved with uplights or wallwashers for indirect lighting. Bright wall surfaces reflect the light softly and evenly into the room. To enable the lighting to be adjusted to different personal needs, all luminaires should be dimmable.

Free-standing side lights with adjustable shades provide sufficient brightness for the

reading area. Uplights and wall or clamp luminaires with an adjustable arm-mounted luminaire head are also well suited for the purpose. The luminaire can thus be flexibly re-positioned if the seated or reclining reader moves.

Good colour rendering – and thus a genuinely good read – is achieved, in particular, through the use of halogen lamps with a colour rendering index of Ra 100.

The best place for a light source is alongside or behind the reader. This ensures that the eye is not dazzled by either direct light from the front or reflected light on the paper.

As a general rule, an older person needs twice as much light as a youngster to experience the same sense of brightness for good visual performance. Sensitivity to glare also increases significantly with age.

## Simultaneous room use with different lighting requirements

Living rooms are often used by different persons for different activities at the same time. To ensure that one person's reading light does not interfere with another person's work at a laptop by creating disturbing reflections on the screen, all luminaires in the room should be appropriately positioned, angled and shielded.

[32-34] A comfortable chair and free-standing luminaire make for a snug reading area.

[33] Shade luminaires lend themselves well to the use of energy-saving compact fluorescent lamps.



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## Lighting tip: Reading light

Combined room and reading light [35]

Uplights with an integrated, adjustable arm provide bright room lighting and accentuated reading light. Ideally, both light sources should be separately dimmable. Ensure that the arm-mounted luminaire head permits flexible adjustment. To avoid glare, the light should fall on the book from above and behind or from above and at the side of the reader. Good specialist lighting shops offer a large selection of combined luminaires – in designs ranging from traditional to modern and with a wide variety of lamp types.



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[36-38] ] A track system delivers light to where it is needed – regardless of where the power outlet is located. The freely positionable spots on the track set accents and highlight selected objects in the room.

[37] ] Many track systems can be used vertically as well as horizontally. They thus enable light to be harnessed to underline and accentuate special architectural features.

**Track systems are effective lighting tools and problem-solvers**

Track systems are ideal lighting tools, offering innumerable possibilities for customised lighting design throughout the home. They can be used both for general room lighting with wide-angle room or ceiling floods and for accent lighting with spots on furniture, pictures or plants.

Because spots, floods and pendant luminaires are easy to reposition on the track, they can be placed wherever they are needed at any time. For a party, for example, where the table is extended for a buffet, the light sources can simply be repositioned to meet the new, temporary requirements. An even better lighting solution for such occasions could be achieved by providing additional luminaires or spots and adjusting the system accordingly. Care must be taken, however, to ensure that the maximum capacity of the system

is not exceeded. In the case of low-voltage systems, it is particularly important to check that the sum of the watt ratings of the spots is no greater than the „VA rating“ of the transformer. A 300VA transformer, for example, has the capacity to operate a maximum of 15 spots with a 20W rating or six spots with a 50W rating.

Many track systems have more than one electrical circuit. This makes it possible, for example, for the lights that illuminate the table to be switched off while others continue to highlight pictures on the wall. For optimum convenience, wireless systems can be used to permit every single light to be individually switched and/or dimmed.

Track systems are also a good solution where – as is unfortunately often the case – only a single ceiling outlet is available in the middle of the room. A track system can deliver light in straight lines, around corners or in curving arrange-

ments to wherever it is needed. To make the room appear larger, systems should be wall-oriented and follow the contours of the room. However, a converse arrangement can also be used to achieve a specific effect. Track lighting that runs across a long, narrow room, for example, makes the room look shorter. And lighting suspended well below a high ceiling makes the ceiling seem lower.

The geometrical - and thus interior design - possibilities of track systems are endless. Installable in linear, L or T-shaped, cruciform, oval or undulating arrangements, they allow the imagination full rein. A specialist lighting retailer, electrical engineer or lighting designer can help you select and assemble the right lighting system.

For safety, the installation work should always be done by a professional.



### Light for pictures and objects

Picture lighting in a living room sets positive accents, adds drama and makes the room look larger by illuminating the walls. Whether originals, prints or photographs, art works bathed in accentuating light stand out from their surroundings and thus develop their full visual impact. The light should fall on the image from above, generated at a point around 1 - 1.5 m from the wall.

### Three picture lighting solutions

Recessed or surface-mounted ceiling spots lend themselves well to picture lighting. Simple and discreet, they make the light and the object the focus of attention. Sadly, the power outlets required are often not available at the points where they are needed. A suspended ceiling or early planning are the answer here. Another option is to mount a gallery track system on the wall. This can be supplied

with electricity from an existing power outlet, a corner of the room or a shelving unit. Another advantage of a gallery track system is its variability. The spots normally project around 40-60cm into the room and can be repositioned on the track to cater for changing arrangements of pictures. These systems are the solution of choice for a room where artworks on the wall are frequently replaced. Gallery track is available in low-voltage and high-voltage systems for halogen lamps or LEDs.

Low-voltage halogen luminaires offer the best and most brilliant light. However, they require a transformer. Where a power outlet is available, this can be mounted on the wall. Alternatively, it can be accommodated in a cabinet or shelving unit at the end of the track. In this case, the transformer needs to display a "M", "MM" or "F" symbol, confirming that it is allowed to be mounted on flammable surfaces. A transformer is not required for high-voltage track systems. These systems

offer the possibility of e.g. incorporating supplementary uplights for the general room lighting.

The third option is to use individual picture lights. These are a solution for setting a lighting accent and emphasizing a single picture on a fairly small wall. They are available in a wide variety of different designs with LED, fluorescent or halogen lamps. LED and fluorescent lamps have the advantage of energy efficiency and the capacity to illuminate large areas. Halogen luminaires consume moderately more energy but have better colour rendering properties.

Original paintings are sensitive to UV radiation. Prolonged exposure to daylight and artificial lighting can cause colours to fade and damage the fabric of the artwork. Special filters that reduce UV and IR radiation should be used to protect valuable paintings. Sculptures often need to be seen in the right light to develop their full visual



impact. Light should be directed onto the object from different directions so that its three-dimensionality is underlined by light and shadow. Narrow-beam halogen spots are a highly suitable option here.

For illuminating objects in showcases, LEDs are the best choice because of their minimal space requirements and low heat gain. Where good colour rendering is needed, halogen lamps are particularly recommended.

[39-42] Illuminating pictures and objects makes them more visually assertive and helps create a pleasant and stimulating lighting atmosphere in the room. Where pictures are mounted behind glass, lighting needs to be angled so that the observer is not disturbed by reflections.



## Lighting tip: Colour rendering

Good colour rendering ensures that the colours of your pictures look as natural as possible [41]: When choosing lamps, make sure you check their colour rendering index ( $R_a$ ). This defines how natural objects look under artificial lighting. Lamps with a  $R_a$  100 rating render objects in perfectly natural colours.  $R_a$  values range from 20 to 100.

For picture lighting, always use lamps with a colour rendering index of at least  $R_a$  80-100. Halogen lamps have the best rating ( $R_a$  100), fluorescent and energy-saving lamp ratings are normally in the  $R_a$  80-90 range.



## Lighting Special: Lighting control, light and colour

Imagine the home as a stage. As in the theatre, light can be harnessed here to transport emotions and create moods - from businesslike to romantic, stimulating to relaxing. Good lighting design offers the possibility of crucially influencing residents' sense of wellbeing.

[43] Mobile LED luminaires can be flexibly used in the home to bathe rooms in coloured light and create seamless colour sequences.

[44] A lighting control system provides the convenience of remote switching and dimming – so no more need for the awkward task of setting each luminaire individually.

[45-46] A sophisticated lighting concept can imbue one and the same room with totally different lighting atmospheres. The blue view shows a fresh morning with diffuse cool light and austere, highly focused warm white accents. The red example simulates a Mediterranean autumn afternoon with warm, directional, soft-edged light and reddish background lighting.

A good play or film develops its drama from skilled use of lighting. Sadly, the lighting found in people's homes often pales in comparison. Drawing inspiration from stage lighting can be very rewarding.

A variable lighting design needs to address three basic functions: room lighting, accent lighting and mood lighting.

Achieving the right mix and catering to different mood and functional requirements call for a variety of light sources with variable luminous intensities.

This forms the basis for differentiated lighting, just as on a stage. Now it is up to the user to switch and dim the lights to suit individual needs. A central lighting control system is very convenient here. It offers the opportunity to save complex lighting scenes and retrieve them as required at the push of a button. Any lighting mood can thus be created – for a party or work

session, a quiet hour with a good book or an intimate evening for two.

Dinner with friends, for example, thus becomes a genuine lighting experience – from the moment the guests are welcomed in bright, widespread light through the aperitif at twilight to the meal itself with intense light over the table and accent light picking out pictures on the walls. Dessert is served in subdued warm indirect mood light, in which the candles on the table are suddenly much more prominent and the conversations perhaps become more intimate and intense.

The interaction of light, time and space here can be harnessed to create a special kind of suspense. Technical requirements include signal receivers in luminaires or junction boxes, which can be retrofitted. Free-standing or table luminaires can also be integrated at a later date by the use of special adapter plugs.



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The signal receivers are addressed by a remote control device, multifunction switch or computer and regulated according to the user's requirements. In new buildings, the data transfer is via cables; where the system is retrofitted, communication is by modern wireless technology.

But the technological possibilities are not confined to just lighting productions and planning. A central control unit – itself remote-controlled by a mobile phone – can perform a wide range of tasks, from turning on the central heating on the way home to simulating an occupied house when the family is away on holiday.

Good systems, installed and programmed by professionals, are easy to operate and meet the challenges of daily use.

For older or disabled persons in particular, such systems are not just a convenience; they are a practical daily tool.

#### Light and colour

Colour has a dramatic effect on the way we feel and is capable of establishing and promoting a sense of wellbeing. Colour psychologists can cite many examples of light colours affecting our sense of warmth

in a room or having a soothing, stimulating or performance-boosting impact.

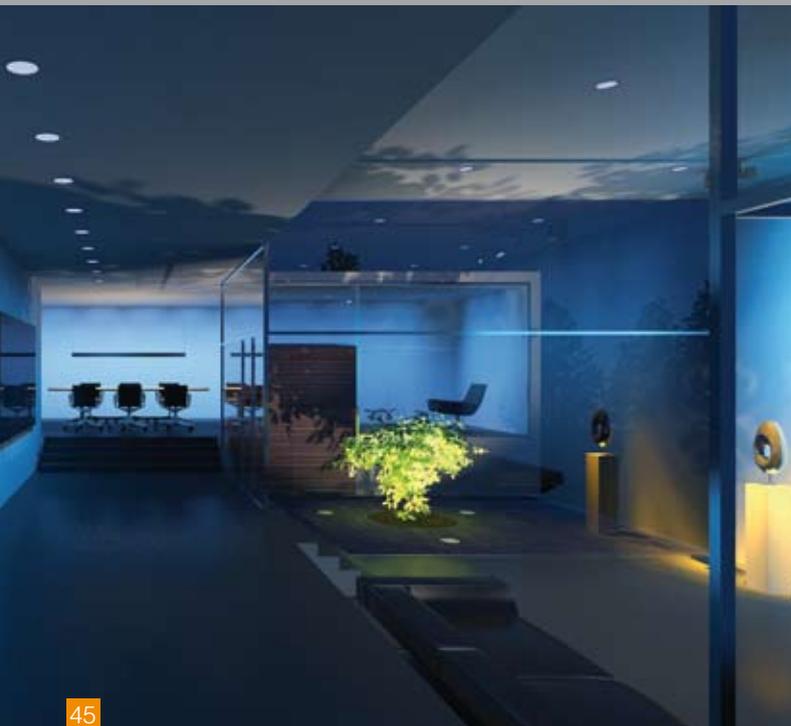
The privacy of the home offers particularly suitable opportunities for casting individual zones in coloured light and thus shaping occupants' emotional response. At the push of a button, for example, a living room or bedroom wall could be bathed in meditative blue, refreshing green or stimulating red light. To support our daily rhythm, warm light colours with a higher red content are preferable in the evening; blue ones should generally be avoided.

Coloured lighting productions are possible thanks to modern RGB control systems for LEDs or fluorescent lamps. These systems work by additive colour mixing, which can produce a theoretical 16.7 million colours from the three primaries (red, green, blue light) by finely adjusting their respective intensities. In most cases, RGB control systems offer the possibility of running through programmed colour sequences at different speeds or setting a selected colour for a static lighting experience. Luminaires with dynamic (colour-changing) RGB control systems have been on the market for quite some time. Since LEDs swept

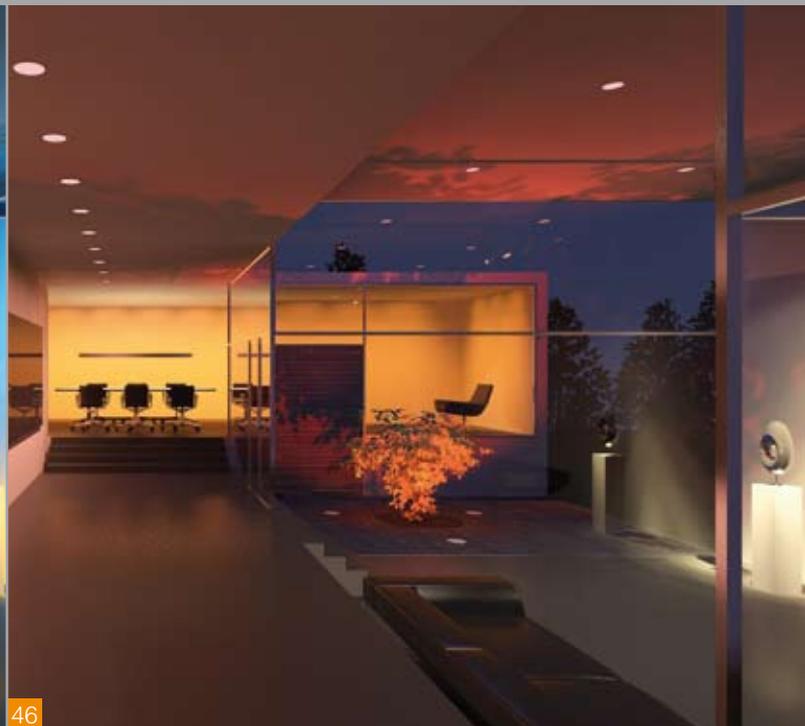
into the domestic luminaire market, LED technology has also become affordable for the private consumer. Here the market offers a wide variety of large and small RGB-controlled lighting objects. However, colour productions over entire walls or ceilings can only be realised with high-performance RGB floods made by quality manufacturers.

RGB-controlled LEDs have also moved into the realm of furniture design. A number of luminaire and furniture manufacturers, for example, market luminous shelves, sideboards or illuminated tables. Anyone who is not interested in a dynamic colour-changing system but still wishes to work with coloured light can fit spots with dichroitic colour filters or coloured lamps.

Specialist lighting retailers, electrical engineers and lighting designers are the best persons to consult on this matter.



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## Dining room lighting

As a central point of the home, the dining room merits special attention when it comes to selecting the right lighting. From intimate family gatherings to big social occasions – everything in the dining room revolves around the table. A place where family and friends gather, it is also a place for playing games, for working and for eating.

The dining table needs to be able to meet a series of changing daily requirements. So the lighting should be flexible. Height-adjustable, dimmable pendant luminaires ensure that the right light is available – not only for eating but also for other activities. Easily repositionable pendant luminaires on wire, rod or tracks systems are the best option here. With some new track systems, repositioning is even possible by moving luminaire heads from below. So there is no need to climb a stepladder to rearrange the luminaires if the table is extended. These systems also permit more luminaires to be added.

One of the primary purposes of table lighting is to illuminate the table top brightly while leaving the persons around it in subdued stray light. Luminaires should be suspended just above eye level. A dining table luminaire

should not obscure the view of the person sitting opposite and must definitely not be a source of glare. The distance between the table top and the lower edge of the luminaire should therefore be around 60 cm. Suitable lighting options here include luminaires with satin or gloss finish opal enclosures, tinted enclosures or closely woven fabric shades.

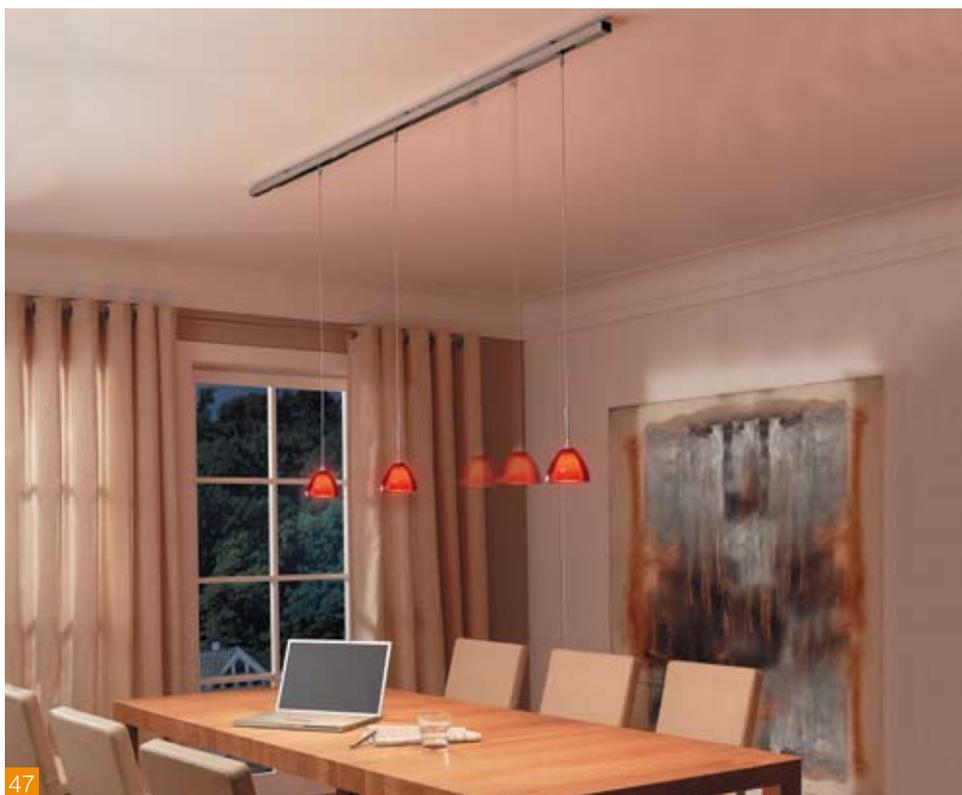
Modern high or low-voltage halogen lamps are recommended for distinctive table lighting with good colour rendering characteristics.

The design of the luminaire(s) should reflect the shape of the table. A round dining table normally calls for a round pendant luminaire, a rectangular one either an elongated model or lights suspended in a linear arrangement.

[47] Track systems and luminaires that can be slid along them are ideal for extendable tables and offer extra flexibility for adjustment to new room situations.

[48] Touch-dimmable pendant luminaires are a particularly practical solution. They enable the lighting to be dimmed for dessert, for example, without anyone having to leave the table.

[50] Colour can be a trump card when it comes to selecting the right luminaire. Care should always be taken, however, to ensure that the table is brightly enough illuminated and the food cast in the right light.





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## Lighting tips: Dining room

**Table lighting [49]:** The distance between the table top and the lower edge of the luminaire should be around 60 cm so that eye contact with the person opposite is possible without glare or obstruction.

**Possible alternatives to pendant luminaires:** Where suspended luminaires are stylistically wrong, ceiling luminaires with highly focused beams can provide alternative zone lighting for a dining table.



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**Supplementary luminaires can be used to create a special room atmosphere**

Creating an agreeable atmosphere requires more than just dining table lighting; it also calls for attractive general lighting. If the space outside the eating area is not illuminated, the room looks cramped and dreary. Free-standing luminaires, wall luminaires or picture lights can be usefully deployed here to set additional accents.

All luminaires in the room should be on separate operating circuits if possible. One of the keys to creating a homely atmosphere lies in the use of luminaires producing different levels of brightness.

Pictures, plants or fine furniture can be emphasized particularly well through the use of light. Flexible spots on wire and rod systems or power track are useful here – especially if not enough power outlets are

available where spotlighting is needed. Good lighting is thus guaranteed even if the room is subsequently rearranged.

All halogen lamps – whether they operate on low or high voltage - have optimal colour rendering characteristics and thus make for a warm and natural atmosphere. They can be dimmed to the point where the light they emit is only just perceptible. This is intimate, cosy and easy on the eye.

[51] Pendant luminaires are a particularly good vehicle for making a personal design statement and expressing personal taste. To ensure that the luminaire chosen gives pleasure for the longest possible time, it is important to consult at length with a specialist dealer.

[52] The use of wall luminaires and lights illuminating pictures makes for a greater sense of space. The lighting accents thus created also enliven the atmosphere and cause the eye to linger repeatedly at different points in the room.

[53] Because of their compact dimensions, LEDs permit luminaires of ground-breaking shallow design. This pendant luminaire is height-adjustable and also saves energy due to modern LED technology.



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# Kitchen lighting

In many families, the kitchen is the hub of the home. On the one hand, it is where the cooking and baking are done; on the other, it is a meeting-point – and often a favourite spot at parties.

A special point to bear in mind about kitchen lighting is that no disturbing shadows should be allowed to fall on work surfaces at the cooker, sink or worktop. Shadows can occur, for example, if the room is illuminated by only one luminaire in the middle of the ceiling, which means that anyone facing the work surfaces stands in their own light. It is better to position luminaires decentrally, near the walls or window. The light then comes from above or the side and is almost shadow-free.

Another important general lighting task is providing sufficient illuminance for all areas where people move around. Recessed or surface-mounted ceiling luminaires and track systems for wide-angle light distribution are particularly good options here.

## Kitchen work surface lighting

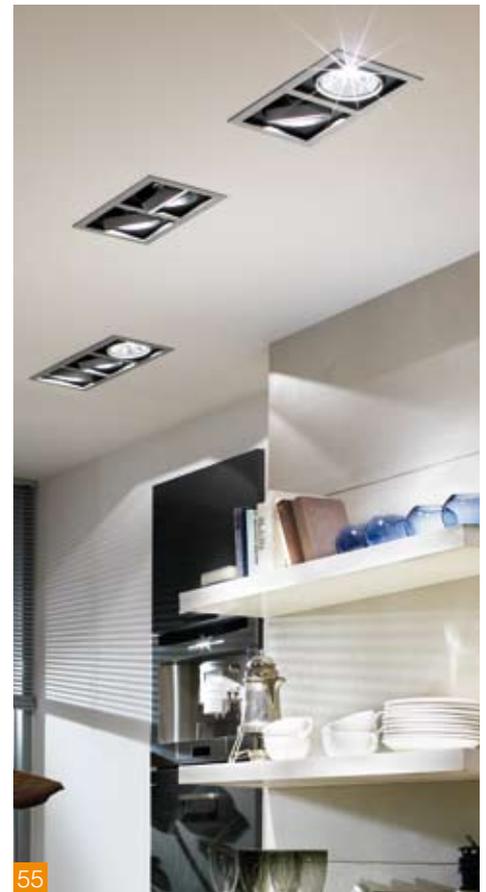
Modern kitchen wall units often come with integrated lighting for the work surfaces below. However, the recommended minimum illuminance of 500 lux here is often not reached.

For the retrofit market, the specialist lighting trade offers a wide range of shallow, high-intensity luminaires for surface or recessed mounting. Care should be taken here to ensure that the luminaires display a “F”, “M” or “MM” fire safety symbol and, wherever possible, have a VDE, ENEC or GS approval mark.

Where there are no wall units over a worktop, suitable lighting can be provided

[54] Thanks to good ventilation systems, kitchens today are often designed as part of an open-plan kitchen and living/dining room. Accordingly, the lighting design needs to be variable to cater for the different zones.

[55] Recessed gimbal spots (set in two integrated rotating metal rings) have made the break from their established application – shop lighting – and extended into the home. Where a suspended ceiling is available, they can provide accent and general room lighting with lots of scope for angling and beam adjustment.



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## Lighting tips Kitchen

**Work surface lighting [57,58]:** Hard shadows on work surfaces should be avoided wherever possible. Separately switched shallow luminaires mounted under wall units should provide at least 500 lux illuminance at the work surface. Make sure they display a "F", "M" or "MM" symbol. These symbols identify luminaires that are suitable for recess and surface mounting on furniture. For further information, see p. 43.

**Kitchen dining area [59]:** As a separate lighting zone, the dining area should always have its own lighting. The distance between table top and luminaire should be at least 60 cm to guarantee a clear view.

by ceiling luminaires and track systems mounted directly above it casting highly focused beams of light onto the worktop.

The advantage: the track carries electricity from the power outlet to where the flexibly positionable luminaires are needed to deliver the right light.

Warm-white fluorescent or energy-saving lamps are a good choice of light source for the kitchen. They emit uniform light over a large area. Modern energy-saving halogen lamps, with their very good colour rendering properties, are also recommended.

#### Cabinet and shelf lighting

Cabinet and shelf lighting can serve two purposes: first, by highlighting fine furniture and its contents, it creates a special atmosphere; secondly, it illuminates the space that makes cabinets and shelves easier to use. Crockery, pans

and foodstuffs are easier to identify and quicker to find.

Track systems, clip-on luminaires and surface-mounted furniture lights as well as ceiling luminaires that act as wall-washers are particularly suitable for the purpose. The distance between ceiling luminaires and cabinets or shelves should be selected so that the latter are fully illuminated from top to bottom and a person standing in front of them does not cast disturbing shadows. The optimum distance on a normal 2.5 – 3 m high ceiling is between 50 and 80 cm.

#### Kitchen dining area lighting

Apart from pendant luminaires, ceiling luminaires with a highly focused beam are a suitable lighting option for the dining area in a kitchen. They should illuminate the table top brightly and bathe persons at the table in agreeable scattered light.

[56] As a separate lighting zone, the dining area should always have its own lighting. The distance between table top and luminaire should be at least 60 cm to guarantee a clear view.

[60,61] Recessed spots in suspended ceilings make for accentuating, brilliant light.

[62] Height-adjustable pendant luminaires can be tailored to user requirements. Illuminated wall units make the room look larger.





# Bathroom lighting

In the morning, the bathroom is where we wake ourselves up to face the challenges of the day; in the evening, we use it mainly to unwind. In order to turn a functional bathroom into a place of wellbeing, special attention needs to be paid to the lighting.

Even in a bathroom, good general lighting is needed for background illuminance in the room.

At least 300 lux illuminance is recommended. In this connection, special attention should be paid to the colours of walls or tiles. Dark areas absorb light and call for luminaires with a significantly greater luminous intensity.

The lighting should definitely be fitted with a dimmer to enable the light to be adjusted for comfort. Subdued lighting makes bathing a more relaxing experience and is less disturbing on a night-time visit to the toilet.

Recessed and surface-mounted spots and ceiling luminaires with white opal glass enclosures are suitable options for general bathroom lighting.

## Three points to note for good mirror and washbasin lighting

The requirements that need to be met for good mirror lighting can be summed up in three sentences. First, the observer's face should be evenly illuminated, i.e. free of any disturbing shadows. Secondly, the light must definitely not dazzle. Thirdly, the face should be rendered in natural, neutral colours.

Uniform, shadow-free illumination is best achieved with light from elongated linear luminaires positioned at each side of the mirror. Supplementary light from above – especially recommended for wider mirrors – is the optimal complement to ensure a perfectly shadow-free face. Light from above alone produces undesirable shadows under chin and nose. Spots directed at the mirror from the ceiling or from right

[63-65] A good specialist lighting shop offers a variety of mirror lighting solutions in different designs. Good mirror lighting is best achieved with satinised white glass diffuser luminaires positioned at the right and left of the mirror. Supplementary light from above makes for optimal ergonomics and illuminates the face fully and without shadows.





and left of the mirror will dazzle the observer and should be avoided.

Luminaires with satinised white glass diffusers and compact fluorescent lamps are ideal for natural, neutral colour rendering. They provide low-shadow lighting over a large area. Warm white is normally the optimal light colour for these types of lamp.

### Small bathrooms look significantly larger in the right light

Indirect light reflected by light-coloured walls and ceilings makes small bathrooms look bigger. Supplementary wall luminaires, e.g. in niches, also make for a greater sense of space. This effect can be enhanced even more by large windows and mirrors.

[66] Wall-mounted spots are an alternative to the conventional mid-ceiling luminaire. They set accents and create zones of light and shadow that enliven the room atmosphere.

[67] In small or guest bathrooms, general room lighting can also be provided by wall lights alone. A ceiling luminaire is unnecessary in this case.



### Redefining sense of space with good wellness bathroom lighting

More and more bathrooms today are designed and used as a multi-purpose room. Although still a place for body and beauty care, they are increasingly expected to incorporate wellness facilities that help us unwind. We spend more time in the bathroom than in the past and our space requirements have increased.

A growing number of bathrooms feature a wellness area with sauna, infrared cabin, steam bath or rain shower. What is more, the borders between other parts of the home, especially the bedroom, are now often blurred. This modern definition of the bathroom presents a new challenge for the lighting designer. Functional zones such as washbasin, wellness shower, whirlpool or even plunge or swimming pool need to be considered separately when it comes to choosing lighting.

Recessed or surface-mounted downlights are one solution able to meet the different requirements. Where a suspended ceiling is not available, or if power outlets are not in the right place, power track systems can be a good choice. They can be fitted with a variety of spots, uplights or floods to cater to the needs of the different functional zones. Another advantage is that the lighting regime can be reviewed and redesigned at any time.

When we bathe in a bathtub or whirlpool, our gaze is generally directed towards the ceiling, so care should be taken to ensure that lighting is glare-free. Punctual light sources on the ceiling at this point could dazzle and disturb. Luminaires that emit indirect light or feature opal glass enclosures are the recommended option here. A dimmer is always desirable.

Many washbasin units, mirrors and showers on the market have integrated lighting. However, the quality of that lighting should be checked.

In many cases, the light provided is insufficient and ergonomically incorrect and needs to be supplemented by other luminaires. If in doubt, consult a lighting professional.

Individual room functions aside, bathroom lighting should create a stimulating atmosphere in the morning and a more soothing mood in the evening to help us relax.



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[68-69] Private wellness or swimming pools call for detailed lighting planning, preferably by an expert. Relaxation areas and functional zones need to be considered separately and optimal lighting solutions developed for each one. This ensures long-term user satisfaction and comfort.

[70] A starry sky in the sauna makes for a sense of wellbeing only if it does not dazzle. Because users normally lie on their back with their eyes directed towards the ceiling, luminous intensities here need to be low. Interesting effects can be achieved with colour-changing fibre-optic systems or LED technology.

[71] Good mirror lighting performs two services: it helps us wake up in the morning and it helps us make the right beauty and body care decisions.



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## Lighting tips: Bathroom

**Creating lighting zones [73]:** Use lighting to distinguish visually the different zones of your bathroom. This makes for an enhanced sense of wellbeing and enlivens the room. Light is an effective tool for distinguishing and emphasizing room zones and functional areas. Recessed ceiling luminaires with a focused beam are a good choice for the shower zone; separately switched lighting at the mirror and above the bath round off the sense of well-lit space.

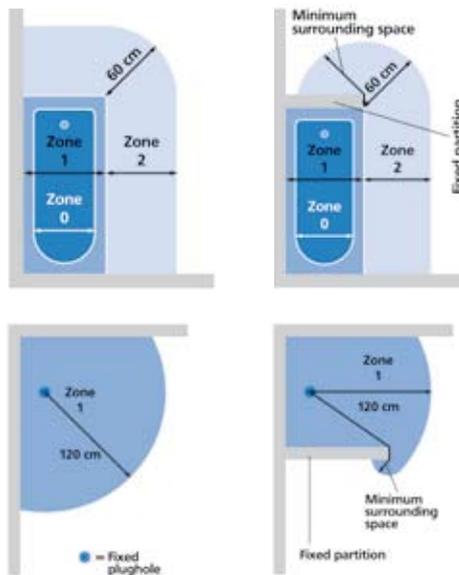
**Mirror lighting [74]:** A single light source at the mirror is not enough for good face care lighting. Light from above or from one side alone gives rise to undesirable shadows under the chin and nose or on one side of the face. Uniform shadow-free illumination of the face is best achieved with light from elongated linear luminaires mounted on the left and right of the mirror. Supplementary light from above is the perfect complement. If fluorescent lamps are used, warm-white is the light colour of choice for a pleasing mirror image.



### Standard-compliant installation by a professional is vital for safety in the bathroom

Safety and compliance with standards are particularly important considerations in a bathroom. The simultaneous presence of water and electricity means that special precautions need to be taken. So electrical installation work should always be performed by a qualified electrician in line with DIN VDE 0100 Part 701. Amongst other things, this standard defines three special safety zones where electrical installations and luminaires need to meet particular requirements.

#### Bathroom safety zones:



Zone 0 relates to the inside of the bathtub or shower tray, e.g. for the use of underwater lamps. Only luminaires operating on a protective extra-low voltage of 12 V or less may be used here; they must also be specifically approved for use in a bathtub or shower tray and need to be protected to at least IP X7 (see table showing degrees of protection).

Safety zone 1 is bounded by the vertical surfaces or planes at the outer edge of the bathtub or shower tray. Where no shower tray is present, the zone extends to a radius of 120 cm around the shower head at rest. The upper limit of the zone is 2.25 m above floor level, the lower limit is the floor. Safety zone 1 (like safety zone 0) requires

the use of protective extra-low voltage luminaires operating on a maximum voltage of 12 V but no transformers may be mounted within its boundaries.

Safety zone 2 is a 60 cm deep strip adjoining safety zone 1. Luminaires in both of these zones require a protection rating of at least IP X4. Where massage jets etc. are installed, luminaires are required to be protected to IP X5.

No switches or sockets may be installed in zones 0, 1 or 2. An exception is made in the case of switches integrated in standard-compliant luminaires.

#### Degrees of protection:

The degree of protection assigned to a luminaire indicates the limits on its safe and reliable operation. The IP code (Ingress Protection) consists of two numerals. While the first refers to protection against solid foreign bodies and dust, it is the second that is most important in a bathroom. It indicates the degree of protection against water and moisture. For example: IP44 identifies a luminaire protected against solid particles larger than 1 mm and against splashwater (see table below). A capital „X“ in place of one of the two numerals means the degree of protection is not specified.

Code numerals	1st code numeral: Protection against foreign bodies and contact	2nd code numeral: Protection against water
0	non-protected	non-protected
1	protected against solid foreign bodies > 50 mm	protected against dripping water
2	protected against solid foreign bodies > 12 mm	protected against dripping water when 15° tilted
3	protected against solid foreign bodies > 2.5 mm	protected against spraywater
4	protected against solid foreign bodies > 1 mm	protected against splashwater
5	protected against dust	protected against jets of water
6	dustproof	protected against powerful jets of water
7	-	protected against temporary immersion
8	-	protected against prolonged submersion ...m

#### Classes of protection:

Luminaires are divided into three classes of protection according to the protective measures taken to avoid electric shock. More on this subject in the Lighting Special overleaf.

[72] Open bathroom design calls for well structured lighting. Individual areas need to be distinguished from one another and illuminated on the basis of different lighting criteria. Dimmer-controlled adjustable downlights in suspended ceilings are a good solution.

# Lighting Special: Safety and standards

Safety must come first in the home. Standard-compliant inspection of luminaires by the manufacturer and professional installation of the lighting facilities are vital to guarantee adequate protection against health hazards, fire and malfunction.

The market surveillance agency of the EU member states periodically examines domestic luminaires and unfortunately often discovers horrifying deficiencies. Many luminaires do not comply with EU legal requirements and have technical defects such as insufficient insulation, incorrect wiring or inadequate strain relief. In many cases, technical descriptions, EU conformity declarations or the CE mark are missing. So wherever possible, the consumer should draw on the knowledge and expertise of the professionals in the specialist lighting trade and, if in doubt, refrain from buying the cheap option that seems such a bargain.

This Lighting Special explains technical terms and describes important precautionary measures. All luminaires need to be tested and type-tested by the manufacturer as a matter of principle. After all, consumer safety is at stake. Important information such as maximum permissible wattage and minimum distance from inflammable materials needs to be displayed on a label affixed to the luminaire. These limits should always be observed; otherwise, the luminaires will present a fire hazard. Luminaire housings can also be rendered live by moisture or water. Where luminaires are designed for permanent installation, the installation work should always be performed by a trained professional. This is particularly important in the event of an insurance claim because insurance cover may otherwise be void.

## Classes of protection

EN 61140 (formerly DIN VDE 0140) divides items of electrical equipment such as luminaires into three classes of protection according to the protective measures taken to avoid electric shock:

### Protection Class I:

In the case of Protection Class I luminaires, the user is protected by live parts being insulated (so-called basic insulation) and by exposed conductive metal parts being connected to a protective conductor (earthing). The protective conductor terminal is marked with an earth symbol (see above). If the basic insulation fails, exposed conductive parts cannot accept hazardous shock voltages. Mobile Class I luminaires are fitted with an earthing pin plug.

### Protection Class II:

In the case of Protection Class II luminaires, live parts are provided with protective insulation in addition to the basic insulation. Connection to a protective conductor is not permitted. Even if luminaires have conductive surfaces, they are protected from contact with live parts by reinforced insulation. Mobile Class II luminaires are fitted with a so-called europlug, a two-pole plug with no protective conductor.

### Protection Class III:

In the case of Protection Class III luminaires, protection is based on the use of a SELV (safety extra-low voltage) system. Typical applications include low-voltage track or wire systems for 12 V operation. The supply voltage is established in conjunction with a safety transformer (or equivalent device) and must be no higher than 50 V (with normal alternating current).

**Degrees of protection (IP) and safety zones in a bathroom**  
see p. 41



## CE mark:

The CE mark is mandatory for products placed on the market in the European Union. By affixing this marking, manufacturers and importers assert – generally on their own responsibility – that their products meet the essential requirements of specific European directives and protection targets.

The abbreviation “CE” stands for “Communautés Européennes” (European Community). However, contrary to what many people think, CE marking is not based on testing by a third-party certification body. Products are self-certified by the manufacturer.

## ENEC/VDE certification symbols



The ENEC certification symbol (EN for European Norms, EC for Electrical Certification) is the European approval mark for luminaires. In Germany, it is awarded in combination with the VDE symbol.

Where products display the VDE/ENEC symbols, it can be assumed that they conform to the current state of the art and thus meet the requirements of the Equipment and Safety Product Act (GPSG). The numeral following the ENEC symbol is a key to the name and location of the certification institute. As well as inspecting products, VDE engineers also monitor production.

## GS mark

The GS mark shows that a product conforms to the German Equipment and Product Safety Act (GPSG) and the relevant EU directive. Awarded by authorised certification agencies, it is based on product safety testing and an assessment of whether operating instructions are clear and complete.

The GS symbol may be used only in conjunction with the logo of the certifying body (e.g. VDE, TÜV). Control audits are conducted to maintain certification. These may involve monitoring production facilities or checking product modifications against the unit tested.

## EMC/EMV mark

The EMC/EMV mark shows that the luminaire or component for which it was awarded has been tested for electromagnetic compatibility.

Electromagnetic compatibility (EMC) describes the interaction between two or more devices in terms of their electrical or electromagnetic effects. Incompatibility can result in interference that ranges from unintended noise from a radio to actual appliance failure.

## Fire protection

For recessed and surface mounting on furniture, luminaires need to bear the “F”, “M” or “MM” symbol and must meet certain thermal requirements.

Mounting surface		Luminaires with the marks			
Flammability	Example	none			
non-flammable	concrete	x	x	x	x
> 200°C	wood		x	x	x
< 200°C	textiles				x

The table above shows the standards and marking requirements that need to be met for a luminaire to be allowed to be mounted on different materials. The mounting instructions must also indicate what recessed and surface-mounting options are available for the luminaire.

To eliminate fire hazards, it is important to observe the required minimum distance from other components, regardless of the nature of the mounting surface.

With luminaires positioned inside cupboards and folding beds, a switch needs to be present to ensure that the luminaires are automatically deactivated as soon as the cupboard is closed or the bed folded away.

## Standards

The aim of standardisation is to promote the national and international exchange of goods and services and prevent technical trade barriers by standardising the requirements that need to be met by tangible and

intangible goods. A standard is a norm or requirement established and published by a standards body or standards organisation. It is designed to set standards and thus improve public safety.

More information and links about standards, approval marks and safety can be found at [www.licht.de](http://www.licht.de).

[75-76] Especially in a bathroom, ensuring safety requires that many different factors should be considered. Electricity and water are elements that need to be strictly kept apart to eliminate the risk of electric shock. Despite the many rules and regulations that need to be observed, there is still ample scope for catering to emotional needs and promoting a sense of wellbeing – e.g. with a lighting design incorporating coloured light.





# Home office lighting

Nearly every home has a place reserved for work. It may be a small corner of the living room or bedroom or it may be a separate room. Everyone needs somewhere to file bills, write letters, check emails. What is often neglected, however, is correct lighting – with negative consequences for eyes and concentration.

[77-80] Good desk lighting can be realised both with desktop luminaires and with pendant luminaires.

[80] High-intensity uplights ensure adequate background illuminance at a workplace.



## Lighting tips: Home office

**Desk lighting [78,80,81]** For a right-handed person, light should fall on the desk from the left to prevent disturbing shadows. For left-handers, the converse applies.

**Light on walls and furniture [78,82]** Illuminated pictures or objects help make for agreeably informal accent lighting. Pictures look particularly colourful and natural when illuminated by lamps with very good colour rendering characteristics, such as halogen lamps.

Bright and, above all, glare-free lighting is a fundamental requirement for working at home in comfortable, ergonomically correct conditions. That requirement needs to be met regardless of whether the office or computer work performed is done in a separate home office or at a workplace set up in the living room.

The general lighting should provide a lighting level of 300 - 500 lux in the room or at least in the area around the workplace. An even spread of brightness in the room boosts our powers of concentration because it means our eyes do not need to keep re-adapting to different illuminance levels.

Ceiling, pendant or free-standing luminaires for indirect lighting are suitable options for a living room workplace. For a dedicated home office, luminaires with linear fluorescent lamps are a more professional solution. The recommended light colour – a colour found particularly agreeable – is warm white. Glare should definitely be avoided, whether it is caused by the lighting itself (direct) or by reflections on the computer screen (indirect).

The second key requirement in a home office is separate desk lighting. It should illuminate the work area uniformly and without glare and ensure the modelling needed for clear identification of objects and details. This prevents early fatigue when working. Flexibly positionable desk luminaires that direct the light to where it is needed are a particularly suitable solution here.

For anyone who wants to save space on the desk, height-adjustable pendant luminaires, free-standing luminaires or articulated arm luminaires that can be mounted on the wall or on a shelf over the desk can be used. Pendant luminaires need to be height-adjustable to eliminate glare or reflections on the screen. For good to very

good colour rendering of objects on the desk, luminaires with halogen lamps are recommended.

Anyone who attaches particular importance to saving energy, however, is well advised to opt for a desk light for energy-saving lamps. For writing at the desk, the rule is: light source on the left for right-handers and on the right for left-handers. This prevents disturbing shadows being cast by the writer's hand.

## VDU workplace ordinance DIN 5035 and DIN EN 12464-1

The German VDU workplace ordinance (Bildschirmarbeitsverordnung) sets out regulations for computerised work places, which also need to be observed for occupational activities conducted in the home. Its requirements are essentially met by compliance with the relevant technical standards. German industrial standard DIN 5035 stipulates minimum illuminance values that need to be maintained. 500 lux and a colour rendering index of  $R_a$  80 - 100 (see also page 13) are recommended for offices.

For VDU work, in particular, marked brightness contrasts and reflections on the screen need to be avoided and the general room lighting must always be activated in addition to the workplace lighting. This prevents the eyes being overtaxed by the constant need to take account of pronounced differences in brightness.

To sum up, the optimum lighting concept consists of two components: indirect room lighting and direct workplace lighting. If these principles are observed, surfing on the Internet, writing emails and even doing paperwork is a lot more enjoyable.



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## Lighting tips: Children's room

**Changing table lighting [86]** Swivel-mounted, dimmable luminaires that do not dazzle the child are required here. A warm light colour makes for a sense of wellbeing.

**Safety a key consideration** Lamps should not be covered with fabric or similar materials. This presents an increased risk of fire.

**Night lighting [87]** Night lights that burn for long periods should be fitted with energy-saving LED lamps or compact fluorescent lamps.

**Desk lighting** For right-handers, light from the left prevents disturbing shadows. For left-handers, light should fall from the right.



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# Children's and teenager's room lighting

For children and teenagers, their own room is not just a place to sleep; it is also a place to learn and play, a home within the home and a private retreat. To cater to all these requirements, every youngster's room needs a good lighting concept.

[83,88] Different luminaires distinguish the various areas of a children's/teenager's room and make for a comfortable atmosphere.

[84,87] A night light within easy reach is important for reading and provides security and comfort for a youngster waking up in the middle of the night.



Children's lighting needs are not actually very different from those of adults. Nevertheless, there are a number of points to remember. To protect young children's sensitive eyes, artificial light sources should be as glare-free as possible. Punctual light sources such as general-diffuse halogen lamps or even high-performance LEDs should therefore be avoided.

Ideally, the background lighting in the room should be dimmer-controlled. This enables a lighting level to be selected that is precisely tailored, for example, to meet the needs of a night-time feed or nappy change. Unnecessary brightness is thus avoided – and the child (and parents) can get back to sleep more easily.

## A night light gives security

One need that many children feel for a long time is the need for a night light. With it, monsters under the bed and robbers in the wardrobe are kept simply at bay. There are various options for providing a night light – from nursery lights incorporating a night-light feature to a wide range of plug-in luminaires. Today, the latter are almost all fitted with LEDs and therefore consume even less electricity than the generation of night lights that preceded them. Obsolete luminaires with halogen or incandescent lamps are a fire hazard and should not be used. With the help of LEDs, night-lighting can even be extended easily into a corridor and thus make it easier for a child to find the way to the toilet.

Please never shade luminaires with fabric or similar materials! Improper application or the wrong type of fabric significantly increases the risk of fire. What is more, different light sources are needed for the different lighting zones in a children's/teenager's room. This zone lighting needs to support functions through various stages of the youngster's life – from night-time

nappy changes to reading in bed, from doing homework to playing and learning at a computer. Appropriate wall, reading and desk lights – preferably dimmer-controlled – render good service here.

Children and teenagers spend a great deal of time at the desk. Sufficiently bright lighting is a must for doing homework. For work at a computer, irritating reflections on the screen need to be avoided. Desk luminaires for compact fluorescent lamps are one answer here.

Safety is a top priority in a nursery. 230 V lamps - i.e. including those for use in an ordinary E27 screw lampholder – should not be placed within a child's reach. Otherwise, the accident that childproof sockets are installed to prevent can quickly happen at the luminaire: an electric shock is certainly possible. Through the use of low-voltage halogen lamps or LEDs with a plug-in power supply unit, all the electrics are reduced to a protective extra-low voltage and thus present almost no danger even for children.

Tailored to children's needs in terms of safety and lighting characteristics and designed to be appropriate for the age group – these are the main points to remember when selecting a luminaire for a youngster's room. It is, in fact, a perfectly straightforward matter - and a fascinating one if the youngster is involved in the decision.

## Bedroom lighting design

We spend nearly a third of our life in the bedroom. It is a private place for rest and relaxation. But the bedroom is also where important decisions are taken – decisions such as choosing an outfit for the day ahead.

First of all, every bedroom needs good general lighting controlled by a switch at the entrance to the room. Suitable options here are recessed or surface-mounted ceiling luminaires, which should provide good illumination for not only wardrobes but also the floor. The second element required is bedside lighting. In the case of a double bed, an appropriate luminaire is

needed for each side, so one person can read without disturbing a sleeping partner. A 20 W low-voltage halogen lamp or an equivalent energy-saving lamp is sufficient for reading, preferably in a luminaire with an angleable head. This can be installed as a wall, clamp or table luminaire but should be separately switched, glare-free and individually adjustable.



In a big enough bedroom, a reading corner creates another island of light

A comfortable armchair and a free-standing luminaire make a cosy corner for reading.

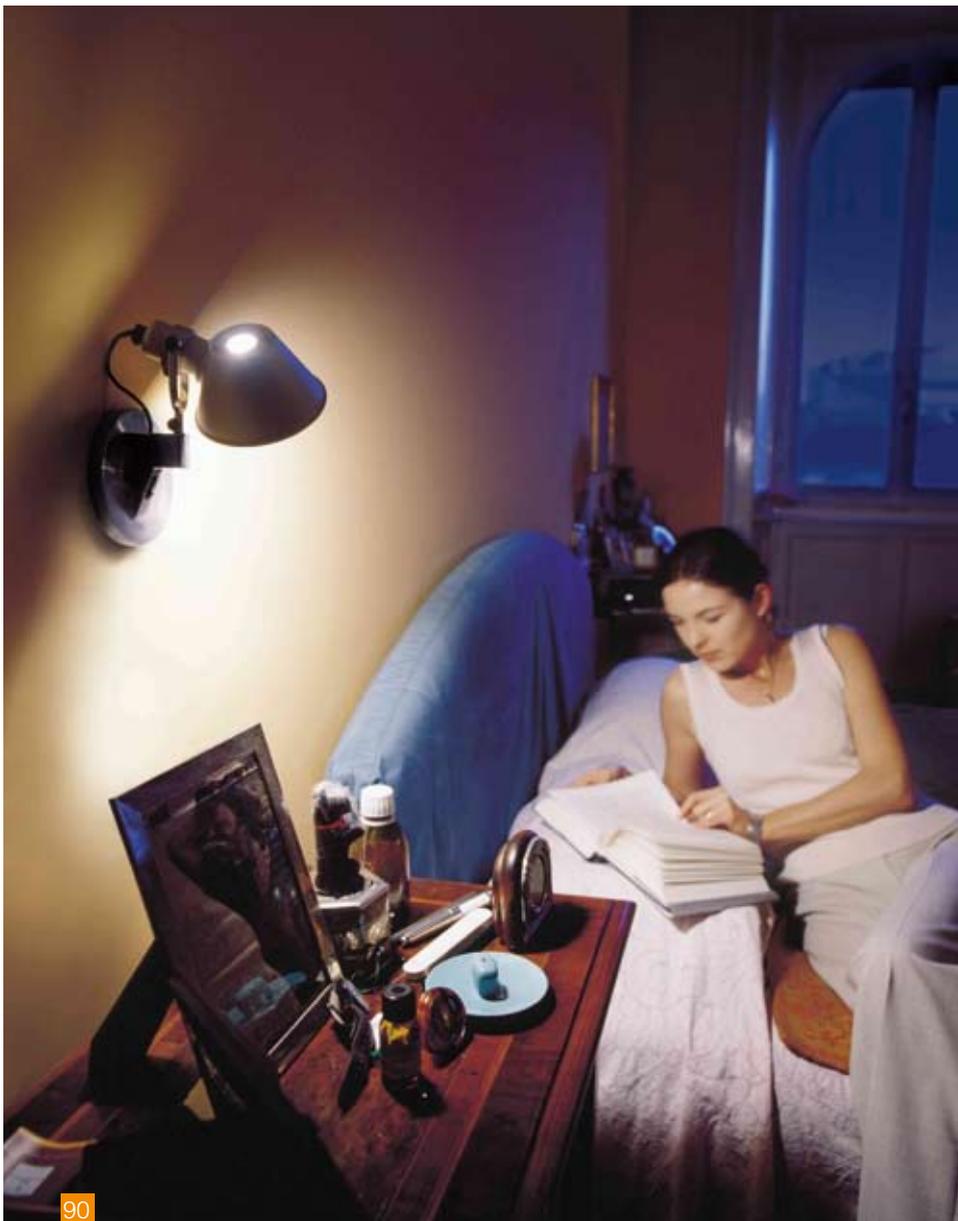
Combined standing/reading lights, e.g. with uplighter and a reading arm, are a good solution. The indirect diffuse room light is found agreeable and thus provides added comfort. The swivel arm furnishes bright light for reading when required. The two light sources should be separately dimmable.

Wardrobe lighting ensures a proper overview of the garments for selection

Wardrobe lighting is another important part of bedroom lighting. Halogen spots mounted in front of or inside the wardrobe facilitate the selection of garments and give the room added atmosphere. The ceiling luminaires should be positioned around 50 – 80 cm from the front of the wardrobe so that the inside of the wardrobe is well illuminated when the doors are open. Colours and fabrics can thus be clearly identified, making it easier to decide on an outfit.

[89] Indirect lighting provides soft ambient light reflected by walls and ceiling. Bedside lights and candles round off the bedroom lighting concept.

[90] Wall luminaires are a good alternative to conventional bedside lights. Their use frees up space on the bedside table.



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## Lighting tips: Bedroom

**Bedside lighting [89-91]:** Ensure that bedside lights are separately switched and, if possible, dimmer-controlled. The light switches at the bed should preferably be wired to control all the luminaires in the room. An additional switch for the lighting around the building gives a sense of security. Provision for these features needs to be made at the construction stage.

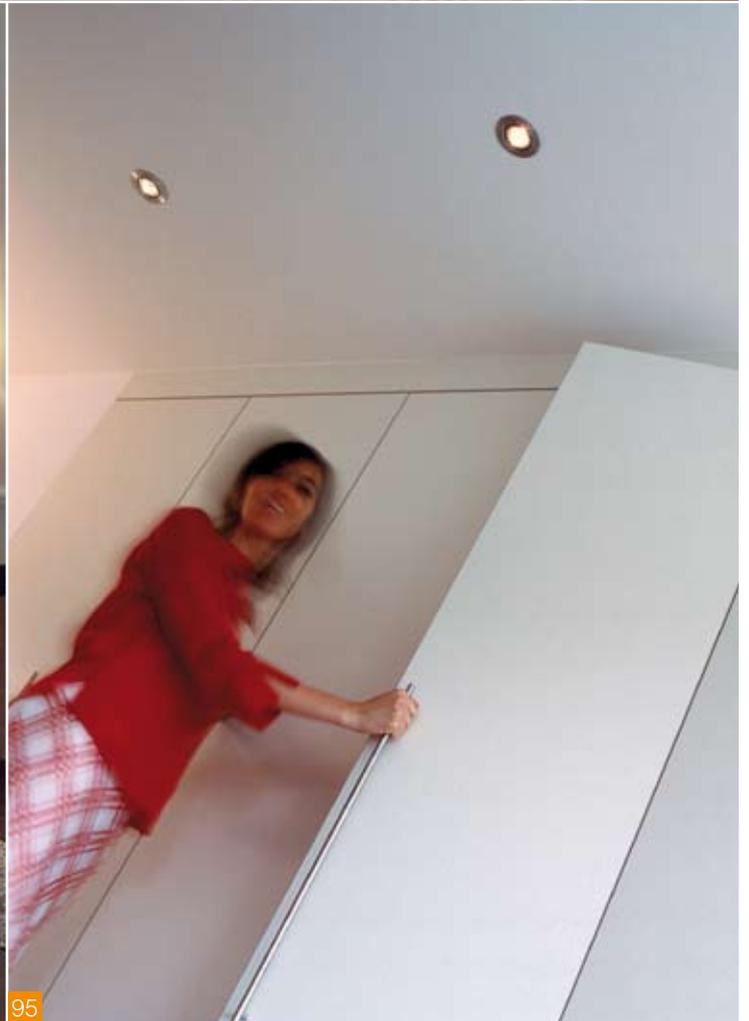
**Mirror lighting [92]:** Correct mirror lighting is also important in the bedroom. The best illumination of the observer is achieved with linear luminaires positioned at each side of the mirror for shadow-free warm-white lighting.



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**Exposure to electromagnetic fields in the bedroom should be avoided where possible**

At night, our immune system and metabolism power down as part of the process of physiological regeneration. Electrosmog or pollutants can significantly interfere with this regenerative phase. So a bedroom should be planned with special care. It is no place for electrical equipment that operates throughout the night, especially devices that require a transformer.

In many bedrooms, power points are located at each side of the bed and are usually joined by a connecting cable. But cabling in the wall can have negative health consequences for a sensitive person.

Demand switches installed by an experienced electrician are one answer here. In a new building, it is advisable to install screened cables and power points at the

outset in order to keep exposure to electromagnetic fields as low as possible.

Ideally, all bedroom lights should be wired so that they can additionally be switched on and off from the bed. This gives a sense of security and offers added convenience in a room where a sense of wellbeing is particularly important.

[93, 96] Early electrical and lighting planning pays dividends in the bedroom. It permits the realisation of special features and lighting effects such as ceiling spots, recessed wall luminaires and precise directional wall spotlights.

[94] Having lots of light sources in the room makes for an agreeable, comfortable atmosphere. A well illuminated makeup mirror can be an additional, upgrading bedroom feature.

[95] For good wardrobe lighting, ceiling luminaires or spots should be mounted around 50 – 80 cm from the front of the furniture. This ensures that the inside of the wardrobe is correctly illuminated when the doors are open.



## Balcony and patio lighting

A well lit balcony or patio extends the home outdoors on warm days. But a good lighting concept pays off on more than just a balmy summer's evening; it also improves the view in winter.

Outdoor lighting should definitely be dimmable. This enables the brightness to be adjusted for different activities, such as reading, playing cards or a cosy tête-à-tête.

Wall luminaires, downlights, permanently installed spots or bollard luminaires are the most suitable options for correct balcony or patio lighting.

Wall luminaires used as wallwashers illuminate the architecture, cast it in a dramatic light and bathe the balcony or patio in the pleasant light reflected by the wall.

An overhanging roof lends itself particularly well to the use of downlights. These are discreet light fittings that provide accentuating light. Care should be taken to avoid glare due to reflections in window glass. Bollard luminaires or permanently installed floor lights supplement the outdoor lighting, especially in the case of large patios.

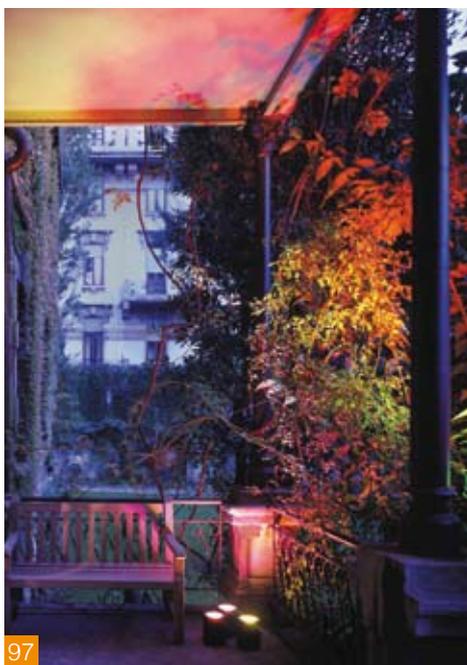
To withstand all weathers, luminaires used outdoors must all be certified for outdoor use and have a high degree of protection. The minimum requirement here is IP 44 (protection against splash-water and foreign solid bodies larger than 1 mm). Depending on where a luminaire is positioned, a higher degree of protection may be required.

Spots can also be deployed on a patio to good effect, e.g. for illuminating plants. Spotlit trees and shrubs look dramatic at any time of year - whether they are in leaf or flower, stripped of foliage or covered in snow.

Even if balconies and patios are not really used much in autumn and winter, versatile outdoor lighting is definitely worthwhile. It visually extends the home outwards and gives a sense of security.

[97] Mobile spots and luminaires with earth spikes in planters add variety and atmosphere. They should be positioned with care to avoid glare. Alternatively, dramatic lighting and colour effects can be created with LED spots set into the flooring. The architecture of the building, sculptures or plants, for example, can be highlighted to particularly good effect.

[98,101,102] A lovely patio needs the right lighting to be really cosy. A variety of light sources indoors and out, dimmed to different brightness levels and combined with candlelight, make for a comfortable, romantic atmosphere.



### Lighting tips: Balcony and patio

**Timely planning [99-100]:** Timely planning guarantees enough power outlets, e.g. for a table grill in summer or, near trees, for Christmas lights in winter. Loose cables that present tripping hazards can thus be avoided at an early stage.

**Photoelectric lighting control [100]:** An automatic actuator for outdoor lighting makes for lighting comfort and security. To save energy, it should ideally be designed to control only the luminaires fitted with energy-saving lamps. The rest of the garden lighting can be switched on manually.



# Lighting Special: Energy efficiency and environment

When Thomas Alva Edison invented the incandescent bulb in 1879, no one had any inkling of the rapid technological developments that were to follow with fluorescent lamps, low-voltage halogen lamps and high-intensity LEDs.

Lighting at present accounts for around 19% of global electricity consumption. Thanks to modern light sources such as energy-saving lamps, energy-efficient halogen lamps and LEDs, significant energy economies can now be made. However, quality of lighting and the actual efficiency of lamps in use must not be disregarded.

**The days of the incandescent lamp are numbered – solutions are available to replace them in a 1:1 swap**

In the conventional incandescent lamp, electricity flows through a filament and heats it to a temperature of 2,900° Celsius. This generates light – but also a lot of heat. What is more, the life of an incandescent lamp, at just 1,000 hours, is very short. In December 2008, the European Commission approved the implementing measure „Domestic Lighting, Part 1“. This prescribes a progressive phase-out of

inefficient incandescent lamp technology by 2012. But consumers need not fear that they will no longer be able to use their present light fittings. Lamp manufacturers long ago came up with acceptable alternatives.

**Progressive phase-out of inefficient technologies**

Relegated to energy efficiency classes F and G, traditional incandescent lamp technology falls short of requirements in 2009. Starting with incandescent bulbs with a 100 W rating or more, all inefficient lamps will be removed from the European market by 2016.

Along with the energy-saving lamps with an energy efficiency class A rating, Class B and C energy-efficient halogen lamps will continue to be allowed. Up-to-the-minute information about the latest EU directives is available at [www.licht.de](http://www.licht.de).

**Halogen lamps**

Halogen lamps work in much the same way as an incandescent lamp, except that halogens are added to the gas in the bulb. A distinction is made between two types of halogen lamp: low-voltage and high-voltage.

The new generation of energy-saving halogen lamps are extremely efficient. Thanks to an inert gas mix, they can lower power consumption by as much as 50%.

In terms of service life (up to 4,000 hours) and luminous efficacy (12-23 lumen/watt) low-voltage halogen lamps out-perform most high-voltage models. Dimmable energy-saving halogen lamps in classic light bulb designs with E27 or E14 base are a new trend.

Where very good colour rendering is required, halogen lamps are particularly recommended because of their  $R_a$  100 colour rendering index.

**Fluorescent lamps / compact fluorescent lamps**

Fluorescent lamps produce ultraviolet radiation by sending an electrical discharge through an inert gas (mixed with mercury). The UV radiation is then converted to visible light by interaction with a fluorescent coating on the inside surface of the glass tube. Compact fluorescent lamps consume up to 80% less energy than a conventional incandescent lamp of the same brightness and have a much longer life. Quality products achieve a colour rendering index of  $R_a$  80 - 90.

A ballast is required to operate the lamps. This is either integrated in the lamp base or incorporated separately in the luminaire. Electronic ballasts are more energy-efficient lamp operators than conventional models.

[103] In order to mitigate climate change, every individual can do something to reduce his or her carbon footprint.



All fluorescent lamps and compact fluorescent lamps contain small amounts of mercury and therefore require separate disposal. They fall within the scope of the Restriction of Hazardous Substances Ordinance. This describes the effect of EC Directive 2002/95/EC forbidding the use of certain substances in the manufacture and processing of electrical and electronic equipment and components

The range of compact fluorescent lamps with screw and pin base is extremely wide. In contrast to budget-priced products, quality lamps made by brand manufacturers have the combined advantages of higher luminous efficacy, lower energy consumption and a longer life. They also offer higher switch resistance and, depending on type, can even be dimmed.

Economy lamps generally fail to meet some or all of these requirements and are thus often the more expensive alternative.

### Light-emitting diodes (LEDs)

LEDs consist of a semiconductor material and can convert electricity directly to light. The energy they require to do so is minimal and their life, at up to 50,000 operating hours, is extremely long. A great deal of light is generated here from very little energy. What is more, the tiny dimensions of an LED mean it can be integrated almost anywhere.

LEDs require a ballast to reduce the 230 V mains voltage to a low voltage. Some LED lamp types have this control gear built in, so they can be used as a direct replacement for e.g. incandescent lamps.

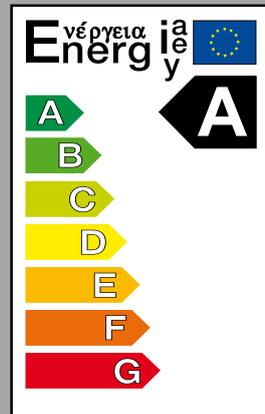
### Appropriate lamp use

Given the different characteristics described above, it is important to decide where a particular lamp can best be used. Because fluorescent lamps do not emit light with a full colour spectrum, they should always be used in the home in combination with energy-efficient halogen lamps. Generally speaking, all luminaires for diffuse room lighting such as uplights, large shade luminaires or light objects for mood lighting are suitable for energy-saving lamps.

All luminaires that emit direct, directional light for accent lighting should ideally be fitted with energy-saving halogen lamps. Because of their diminutive size, LEDs lend themselves well to being integrated in walls, floors, furniture, etc.. Coloured LEDs are particularly good for setting colour accents.

### Energy efficiency classes

The EU Energy Label indicates how energy-efficient a lamp actually is, assigning it to one of a series of "energy efficiency classes". These range from "A" (very efficient) to "G" (inefficient). Conventional incandescent lamps consume so much electricity that they reach no higher than class D. Regular 230 V halogen lamps are also assigned class D – or even class E - status. Modern energy-saving halogen lamps, however, reach class C or even B. But the most energy-efficient lamps of all are energy-saving lamps; they get class A or B ratings. Some labels display additional information about the luminous flux, power input or life of the lamp.



Because of the dynamic advances in LED energy efficiency, LEDs are not covered by this system. However, quality LEDs from brand manufacturers are extremely efficient.

### How can costs be reduced?

The table below compares the efficiency, longevity and thus cost of energy-saving lamps and conventional incandescent lamps.

	Energy-saving lamp <sup>1)</sup>	Incandescent lamp
Wattage	11 Watt (W)	60 Watt (W)
Operating time	8,000 hours	8,000 hours
Life	8,000 hours	1,000 hours
Power consumption over operating time	88 kWh	480 kWh
Cost of electricity at 0.18 euro/kWh <sup>2)</sup>	15.84 euro	86.40 euro
+ Price of lamp(s)	12.19 euro	7.12 euro <sup>3)</sup>
Total cost	28.03 euro	93.52 euro
<b>Saving</b>	<b>65.49 euro</b>	

1) The calculation applies analogously to compact fluorescent lamps with pin base.  
 2) kWh = kilowatt hour  
 3) Price of 8 incandescent lamps at 0.89 euros each

### Calculation example: 3-room apartment

	Number of luminaires	in the past	now	saved <sup>1)</sup>
Kitchen	2x	75 W	15 W	172,80 euro
Bathroom	1x	75 W	15 W	86,40 euro
Hall	2x	60 W	11 W	141,12 euro
Living room	3x	60 W	11 W	211,68 euro
Children's room	2x	75 W	15 W	172,80 euro
Bedroom	3x	60 W	11 W	211,68 euro
<b>Total amount saved:</b>				<b>996,48 euro</b>

1) Cost of electricity saved after incandescent lamps are replaced by energy-saving lamps, calculated on the basis of 8,000 operating hours at an average electricity price of 0.18 euro/kWh.

### How to calculate the costs:

1 kilowatt hour = kilowatt x hours  
 1 kW = 1,000 Watt (W);  
 Price of electricity e.g. : 0.18 €/kWh;  
 An operating time of 8,000 hours is equivalent to 3 hours operation a day for approx. 7.3 years.

### Cost of electricity for 60 W incandescent lamp

$$0.06 \text{ kW} \times 8,000 \text{ h} \times 0.18 \text{ €/kWh} = \text{€ } 86.40$$

### Cost of electricity for 11 W energy-saving lamps

$$0.011 \text{ kW} \times 8,000 \text{ h} \times 0.18 \text{ €/kWh} = \text{€ } 15.84$$

**Saving: 70.56**



Lamp type		Three-band Ø 16mm dia., high luminous efficacy	Three-band Ø 16mm dia., high luminous flux	Three-band Ø 26mm	Three-band 1-, 2-, or 3-tube lamp	Three-band elongated design	Three-band 4-tube lamp	Three-band incandescent-shape	Three-band 1-, 2-, or 3-tube lamp	Halogen lamp shape <sup>3)</sup>
Characteristics	Lamp category	1	2	3	4, 5, 6	7	8	9	10	11
		Linear fluorescent lamps			Compact fluorescent lamps					
Power rating (W)	from to	14 35	24 80	18 58	5 70	18 80 <sup>2)</sup>	16 38	5 23	5 23	18 140
Luminous flux <sup>5)</sup> (lumen)	from to	1,100 3,300	1,650 6,150	1,350 5,200	250 5,200	1,200 6,000	1,050 2,800	150 1,350	250 1,550	200 2,800
Luminous efficacy <sup>5)</sup> (lumen/W)	from to	79 93	69 88	75 <sup>1)</sup> 90 <sup>1)</sup>	50 82	67 87	61 78	30 59	50 67	11 20
Light colour		ww, nw, dw	ww, nw, dw	ww, nw, dw	ww, nw, dw	ww, nw, dw	ww, nw, dw	ww	ww,	ww
Colour rendering index R <sub>a</sub> (in some cases as range)		80-85	80-85	80-85	80-85	80-85	80-85	80-89	80-89	100
Base		G5	G5	G13	G23; G24; 2G7; GX24; GR14q	2G11	2G10; GR8; GR10q	E14; E27	E14; E27	E27

# Lamps



## Three-band fluorescent lamps (1, 2, 3)

Three-band fluorescent lamps offer high luminous efficacy coupled with good colour rendering and a long life. In conjunction with electronic ballasts (EBs), they achieve even higher luminous efficacy, a longer life and greater lighting comfort. 16 mm-diameter T5 lamps are designed for EB operation only. With appropriate EBs, all three-band fluorescent luminaires can be dimmer-controlled.

## Compact fluorescent lamps (4-10)

Compact fluorescent lamps have the same characteristics as three-band fluorescent lamps. Here too, luminous efficacy, service life and lighting comfort are enhanced by electronic ballasts and dimmer control is possible with appropriate EBs. In some versions (9, 10), the ballast is integrated. Compact fluorescent lamps consume up to 80% less energy than incandescent lamps and have a much longer life.

## 230 V halogen lamps (11, 12, 13, 14, 15)

Halogen lamps for mains operation produce an agreeable white light with good colour rendering properties. They have a longer life than incandescent lamps and achieve higher luminous efficacy. They are fully dimmable and available also as reflector lamps. The latest generation of energy-saving halogen lamps reduces power consumption by up to 50%.

## Low-voltage 12 V halogen lamps (16, 17, 18)

Low-voltage halogen lamps produce an agreeable white light with very good colour rendering properties. To operate them, a transformer is needed to reduce the voltage to 12 V. With appropriate transformers, they can be dimmer-controlled. IRC (Infra-Red Coating) lamps consume up to 30% less energy for the same luminous flux.

## Light-emitting diodes (19, 20)

LEDs (Light Emitting Diodes) come in numerous shapes and colours. They are extremely small, consume very little energy and have a high resistance to impact. They also have a very long service life. LEDs operate on direct current. Currently in vogue are LED retrofit lamps in traditional lamp designs, e.g. with E27 or E14 base. They come with an integrated ballast and can thus be simply exchanged for conventional incandescent lamps.

<sup>1)</sup> Luminous efficacy increases to 81 – 100 lm/W with EB operation. The power input of the lamps is reduced from 18 W to 16 W, from 36 W to 32 W and from 58 W to 50 W.

<sup>2)</sup> 40 W, 55 W and 80 W only with EB

<sup>3)</sup> Also available in different shapes

<sup>4)</sup> Value stated in candela (=luminous intensity)

<sup>5)</sup> At 25° ambient temperature

<sup>6)</sup> For neutral-white light colour

<sup>7)</sup> LED colour rendering depends on the type of LED

**ww** = warm white  
colour temperature below 3,300 K  
**nw** = neutral white  
colour temperature 3,300 – 5,300 K  
**tw** = daylight white  
colour temperature above 5,300 K

Halogen reflector lamp <sup>3)</sup>	Halogen pin base lamp	Halogen lamp base at both ends	Halogen reflector lamp <sup>3)</sup>	Halogen reflector lamp	Halogen pin base lamp <sup>3)</sup>	Halogen pin base reflector lamp	LED lamp incandescent-shape <sup>3)</sup>	LED reflector lamp <sup>3)</sup>
12	13	14	15	16	17	18	19	20
230 V halogen lamps				12 V halogen lamps			LED	
40	25	60	20	20	5	10	7	5
100	75	2,000	75	50	90/100	35		7
650	260	840	380 <sup>4)</sup>	500 <sup>4)</sup>	60	800	230 <sup>6)</sup>	800 <sup>4)</sup> <sup>6)</sup>
2,400	1,100	44,000	950 <sup>4)</sup>	2,850 <sup>4)</sup>	1,800	1,000		
-	10	14	-	-	12	-	37	37
-	15	22	-	-	20	-		
ww	ww	ww	ww	ww	ww	ww	ww, nw	ww, nw
100	100	100	100	100	100	100	7)	7)
E14; E27	G9	R7s	GZ10; GU10	GU5.3	GY 6.35; G4	GY 6.35; G4	E27	E27; GU10

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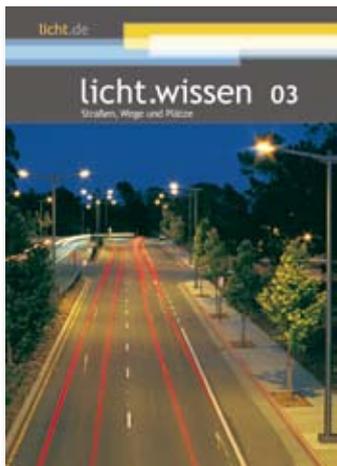
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**[Booklet 10]** 40 pages on emergency and safety lighting: Booklet 10 contains information about standards and stipulations for the operation of emergency and safety lighting systems and explains when and where such systems need to be installed.



**[Booklet 17]** 28 pages of information on LEDs. Booklet 17 describes how the tiny semiconductor crystals work, explains the technology behind LEDs and LED modules and presents exemplary LED applications.

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# All about light!

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The booklets 1 to 18 of the licht.wissen series of publications (formerly: Information on Lighting Applications) are designed to help anyone involved with lighting – planners, decision-makers, investors – to acquire a basic knowledge of the subject. This facilitates cooperation with lighting and electrical specialists. The lighting information contained in all these booklets is of a general nature.

## licht.forum

licht.forum is a specialist periodical focusing on topical lighting issues and trends. Generally around 12 pages long, it is published at irregular intervals.

## www.licht.de

The industry initiative also presents its knowledge of lighting on the Internet. Its website [www.licht.de](http://www.licht.de) features a "Lighting for the Home" portal and a "Lighting for Professionals" section offering practical tips for private and professional lighting applications.

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Ideas for  
Good Home Lighting



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