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Office Lighting: Motivating and Efficient



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Editorial

“What is this for?”
“It’s blue light”
“What does it do?”
“It turns blue.”
“I see.”



In “Rambo 3”, Sylvester Stallone is probably unaware of the effects of the blue content of visible light on melatonin production in the human body and its circadian rhythm. He certainly knows nothing about the third daylight-sensitive photoreceptor that acts alongside rods and cones in the eye as a regulator of our sense of wellbeing.

Not so important for Rambo to know, perhaps, but vital for anyone involved in creating buildings and work environments with different lighting situations. Lighting designers need to give thought to daylight, luminance distribution, dynamic lighting scenarios and their management.

But before solutions are found in the form of colours and other “feats of light”, the requirements of the employer that is to be ‘illuminated’ need to be studied, thought through and defined. Here, light is one of a number of factors needed to help the employer achieve its goals.

To enable corporate strategies to be successfully translated into property strategies – and then lighting strategies – it is advisable to look at the requirements in four dimensions: cultural, social, organisational and economic.

*Among the “cultural” questions that need to be addressed are: What is the organisation’s guiding vision? What are its key values? How should the organisation, the corporate brand, be perceived – or rather experienced – internally and externally? Every building, every room is an expression of corporate culture with an impact on motivation. **Lighting needs to reflect culture.***

*Buildings play a central role as working and living environments. Work-life balance, promotion of commitment, concentration and communication – in short, a productive atmosphere that needs to be precisely defined – are important considerations. Ergonomics and health – evidence that employees are and feel appreciated – are factors for success. For only where social aspects are considered can motivation be strengthened and spread. **Lighting needs to be tailored to tasks.***

The accelerating pace of procedural and structural change calls for organisational flexibility. Entities with mobile, networked workplaces due to increasing value chain digitisation need to be particularly dynamic. Versatile buildings need adaptable lighting. Lighting needs to be flexible.

*Lighting concepts also need to meet economic requirements. Innovative, energy-efficient lighting solutions with an acceptable price tag are sustainable only if they fulfil their defined purpose throughout the entire life cycle of the property. **Lighting needs to be reliable.***

A sustainable building is economical and efficient and increases productivity; as a physical expression of an organisation’s attitude towards employees, customers, partners and society, it also helps define its identity. And lighting, as part of the building “system”, does exactly the same.

Light does all this. It does not just turn blue.

Andreas Leuchtenmüller, Managing Director M.O.O.CON



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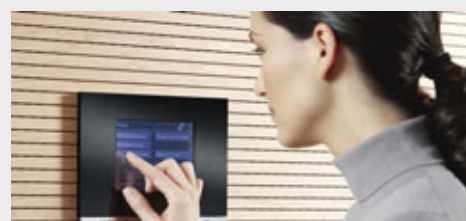
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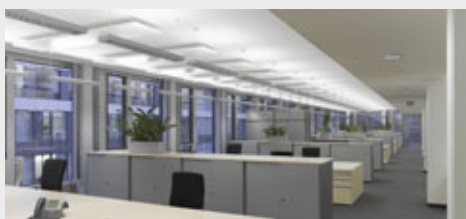
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The office – workplace and living space

Digitisation and globalisation are transforming office work and the way it is organised. In the knowledge society, it is more important than ever that office workers develop solutions from information. New room concepts promote creativity, correct lighting helps provide the motivation for good performance.

Sitting at a desk from 8 to 5? For many of the 18 million Germans with an office job today, those days are long gone. Part of their work is performed on the move, on clients' premises or at home. Emails are checked on a smartphone, research is done on a laptop at the airport, appointments are made by mobile phone.

New technologies and globalisation have transformed office life. Knowledge is the crucial resource. Nearly four fifths of all working people in the developed world today earn their living by knowledge-based activities. So it is all the more important to create office environments that cater first and foremost to employees and their needs: because employees are the ones that turn information into knowledge, develop projects as a team and forge new ideas with colleagues.

Think-tank

So the office of the future is – more than ever – a place for interaction. It is a place for exchanging information and ideas, a control centre and think-tank, a knowledge

interface where communication, cooperation and creativity lay crucial foundations for the success of the enterprise.

For 80 percent of all employees, “general sense of wellbeing in the office” is the main rating criterion for a workplace. That was revealed by a survey conducted in February 2011 by the market research institute Ipsos.

Rooms for creative knowledge workers

Against that background, more and more employers are asking themselves this question: How can employees be better supported, how can their creativity, flexibility and motivation be increased? As a study by the Fraunhofer Institute for Work Science and Organisation (IAO) shows, optimal office workplace design plays a major role here: in companies where design and furnishings are of a high quality, productivity increases by as much as 36 percent.

One-person and cellular offices on long corridors behind closed doors do not offer a physical environment conducive to inno-

[02] Office designs for the modern knowledge society are spacious and open. Work is performed not only at a desk but also in business lounges and at the espresso bar. Good lighting plays a major role in helping to ensure that employees and customers feel at home in the “living space office”.

[03] Optimal lighting facilitates the performance of visual tasks at the workplace and promotes communication.

Five theses on the office environment

In its 2010 “Trend Report on Office and Working Environments”, office expert Bene bundled together major developments and issues in the world of workplace design and floated five theses on the shape of things to come at the workplace:

1. The office of the future will be a knowledge factory.
2. Desk and computer will count less than space and dialogue.
3. Working life will be defined by cooperation and networking.
4. The office of the future will be a cult office.
5. Human technologies will cater to human needs.



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vative work and communication processes. Modern room concepts re-interpret the office designs of the 1970s: the office is seen as living space, offering areas for work, communication and regeneration.

Sustainable workplaces

Like a city, these “creative offices” or “open offices” form a complex infrastructure made up of different zones – as individual as the activities in which their occupants engage. The focus is on communication and knowledge exchange; creative cabins and work boxes are available for work that requires seclusion. Employees select the work space most suitable for the task they need to perform. The office is transformed into an inspiring environment that is good for health and motivation.

Sustainable office concepts will become increasingly important in the future, say scientists at the Fraunhofer IAO. Under the banner “Green Office”, the institute groups office designs that take account of not just economic but also environmental and social aspects. Such concepts increase the sustainability of office work and thus improve a company’s productivity and efficiency, the work-life balance and wellbeing of its employees and its environmental footprint.

Lighting for the “living space office”

These new space-efficient open office landscapes require intelligent furnishing systems that create interesting structures, permit flexible arrangements and visually define the various zones.

Light plays a key role in the optimal design of the “living space office”. Daylight needs to be harnessed wherever possible. Correct lighting not only paves the way for good visual conditions and workplace satisfaction; in conjunction with space, furnishings, acoustics and communications technology, it plays a major role as a design tool – because light creates atmosphere. Innovative lighting technology, efficient light sources and lighting management systems heighten the lighting comfort at the workplace and help save energy and maintenance costs. The place of static, often standardised lighting concepts is taken by flexible solutions offering dynamic, high-quality lighting that can be regulated as required.

Sustainable lighting solutions integrate the specific requirements of an office or administrative unit into an overall concept that takes equal account of the interests of occupants, operators and investors.

[05] Lighting creates atmosphere and is an important design tool in conjunction with architecture.

[06] Modern lighting technology ensures optimal workplace lighting: the light of the free-standing luminaires is regulated according to incident daylight and activated or dimmed as required.

Creative Offices

Cellular offices on long corridors are still a frequent sight but not a solution for the knowledge society. Any attempt to encourage creative work needs to involve closer employee networking. Even where desks are just ten metres apart, colleagues converse only three times a week on average. That does little to encourage creativity in a company. Open office landscapes [04] promote exchange: they combine the advantages of conventional one-person and team offices with a spacious room atmosphere. The focus is on communication and quality of interaction; rooms are available as retreats for recharging batteries or for work that requires concentration. New room concepts allow employees to choose how they wish to work and at the same time reduce the space required to do so by up to 30 percent.





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Good light for a better working environment

Offices and office buildings call for creative lighting solutions. Good lighting inspires, promotes corporate culture and creates optimal working conditions for employees.

Open-plan office a nightmare? Properly planned, it need not be. According to the findings of a Forsa survey conducted in 2011, open office designs with space for team and solo work are far better than their reputation. The researchers found that 83 percent of employees working in large open offices are happy with their workplace; 20 percent are even very happy.

Employees want bright rooms and good lighting

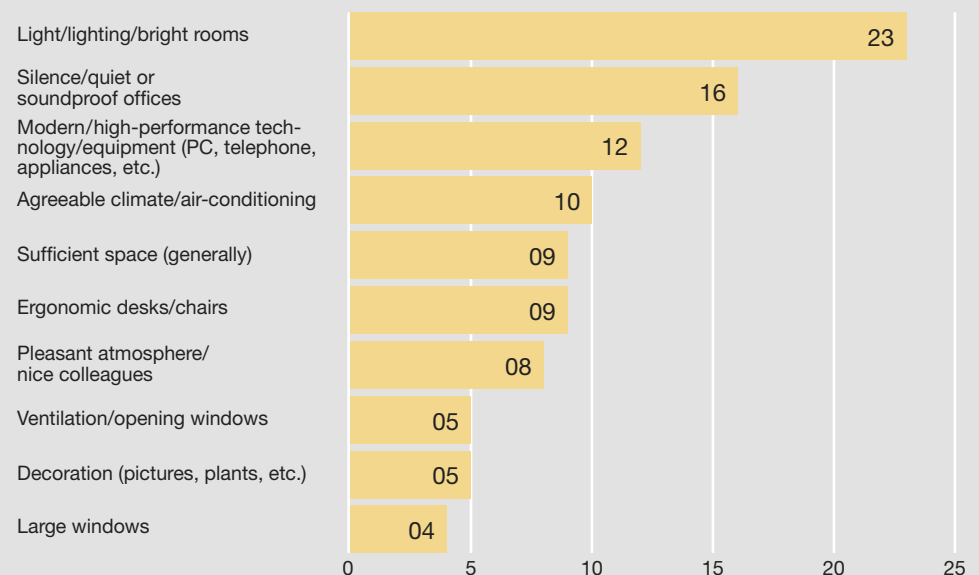
So open office layouts also a thumbs-up from employees. But satisfaction is only achieved where architecture, space and design are of the right standard and where workrooms are tailored to occupants' needs. Major criteria here include spacious, attractive premises with an agreeable atmosphere and ergonomic furniture, a stimulating colour scheme, rest areas and, above all, high lighting quality. Employees rate the latter as the single most important criterion for an ideal workplace.

Light impacts on our mind and spirit more than any other medium. Both daylight and artificial light play a key role in determining the health and wellbeing of employees. Light facilitates visual tasks in the office, creates optimal conditions for communication and concentration and contributes substantially to higher productivity:

- Better visual conditions make for better visual performance at a desk, during presentations and in an interview; they also help boost concentration.
- Agreeable lighting creates an emotional bond with the workplace and has a motivating effect.
- Adjusting lighting according to the time of day and season as well as to individual needs increases user satisfaction.

Conversely, inadequate lighting has a negative impact on performance. The probability of mistakes being made increases.

Criteria for an ideal office workplace



Source: Union Investment, survey of 3,145 office workers in Germany, February 2011.

Question: "If you were to imagine the ideal office workplace for you, what would you consider particularly important?"

[07 – 09] High lighting quality guarantees optimal working conditions: anyone who can see well and feels comfortable in an agreeable room atmosphere is more motivated and more efficient.

[10] A survey commissioned by Union Investment revealed that office employees attach particular importance to light, lighting and bright rooms.

Reducing absenteeism

A good lighting installation is also a good investment because of its effect on down time: accidents are reduced and sick rates fall. Poor lighting leads to fatigue, headaches and illness. Major causes of absence are headaches (57%), back, neck and shoulder complaints (66%) and eye problems (42%).

With optimised lighting solutions that cater for all visual tasks and take account of personal needs, health problems can be significantly reduced and visual complaints cut by more than 50 percent.

Light for older employees

Good lighting for older employees is particularly important. In the wake of demographic change, the number of employees aged 50+ is going to rise sharply. Lighting needs to make allowance for that because the older we get, the more light we need. Catering to that need for more light means raising lighting levels but careful consideration also needs to be given to heightened sensitivity to glare, which is

another issue as we get older. Moreover, workplace lighting should permit individual adjustment to meet personal or task-specific requirements.

Lighting quality in the office

Professional lighting design today takes account of three dimensions of lighting quality:

- Visual quality: good light is essential for unimpaired vision and recognition of visual tasks, promotes visual performance and enhances visual comfort.
- Emotional quality: daylight and artificial lighting cast architecture and the workplace environment in the right light, make for atmosphere and a sense of wellbeing.
- Biological quality: light synchronises human biorhythms, regulates waking and sleeping phases and has a major influence on health and performance.

Employees and their expertise are an employer's most important resource and also the biggest cost factor. Hence the axiom: the company that invests in its employees' health and wellbeing gets a motivated and powerful team.

[11] Good lighting in office buildings offers lots of advantages: it boosts employee motivation and performance and creates atmosphere.

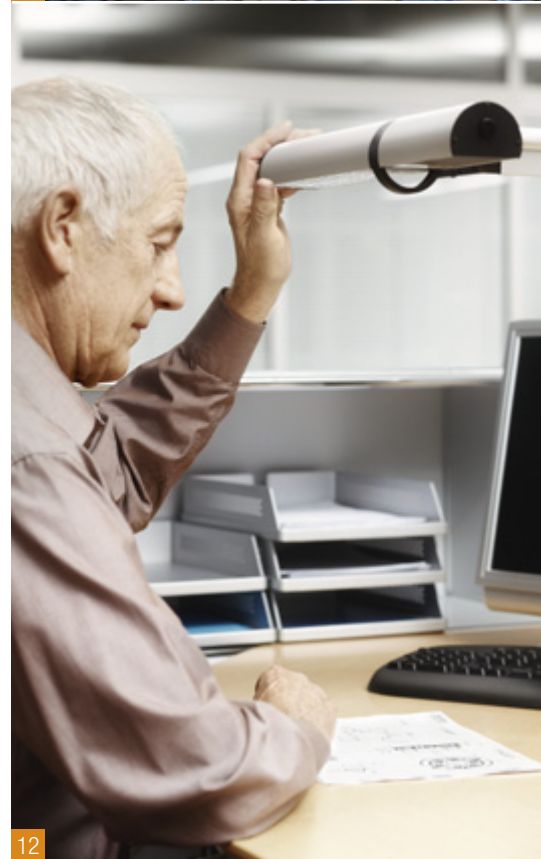
[12] Older people need more light than their younger colleagues. Supplementary light is provided by well-shielded desk lights.

[13 + 14] Field research shows that health problems and complaints about the working environment are reduced when the lighting situation is improved (Source: www.ergonomic.de/LichtundGesundheit.htm based on the study by Cakir, A. and Cakir, G.: "Licht und Gesundheit: Eine Untersuchung zum Stand der Beleuchtungstechnik in deutschen Büros", Ergonomic Institut für Arbeits- und Sozialforschung, Berlin, 1998).

[15] Agreeably uniform glare-free light in the office is provided by recessed luminaires; downlights mark the aisle area.



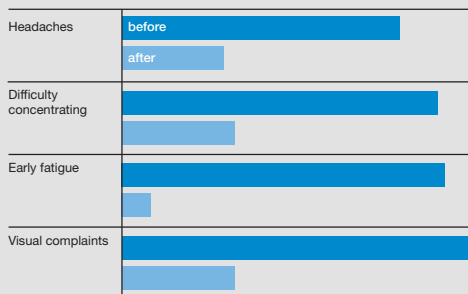
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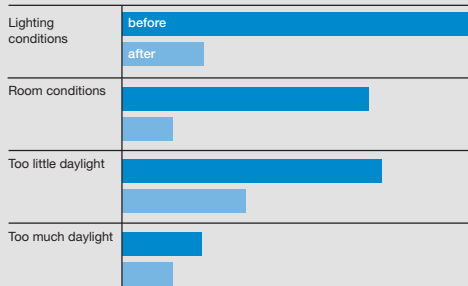
Fewer health problems with better lighting



Source: Ergonomic Institut Berlin

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Fewer complaints about the working environment with better lighting



Source: Ergonomic Institut Berlin

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Lighting concepts and design

The right lighting ensures an agreeable luminous environment in office and administrative premises. Indeed, it is a prerequisite for good visual performance and contentment. To take account of the diverse requirements that need to be met for ergonomic and photometrically correct lighting, professional design is essential.

First and foremost, lighting needs to ensure that all visual tasks at the workplace can be performed satisfactorily with no adverse impact on health. Visual tasks need to be clearly visible and any interference, e.g. by glare, must be avoided. New lighting concepts are based on concrete lighting needs and focus on the visual task in question. In Germany, it is advisable at the design stage to observe workplace regulation ASR A3.4. This ensures that the relevant requirements of the Arbeitsstättenverordnung (Workplace Ordinance) are met. DIN EN 12464-1 is the generally accepted standard. ASR A3.4 and DIN EN 12464-1 were revised in 2011.

The standard defines lighting for the visual task area, the activity area and the room zone. The visual task area is fringed by the immediate surrounding area. A balanced mix of required brightness levels is the correct choice for all task areas. Lighting can be designed on the basis of one of the three following concepts.

Room-related lighting

Room-related lighting provides uniform lighting throughout the room. It is recommended where the arrangement of workplaces is not yet known or needs to remain flexible. This lighting concept is generally realised with direct/indirect pendant luminaires or large-area luminaires in and on the ceiling.

Task area lighting

A second lighting concept focuses on the workplace. In this case, task areas are provided with at least 500 lux illuminance. The rest of the room, excluding a 0.5 metre periphery, is the immediate surrounding area and is illuminated to at least 300 lux. Task area lighting is recommended for rooms where diverse visual tasks are performed with different illuminance requirements. It is also an option where workplace clusters need to be clearly distinguished.

Direct surface-mounted luminaires, pendant luminaires or free-standing luminaires for

direct/indirect light distribution are suitable options for task area lighting. Lighting for the immediate surrounding area can be provided by e.g. downlights.

Work surface lighting

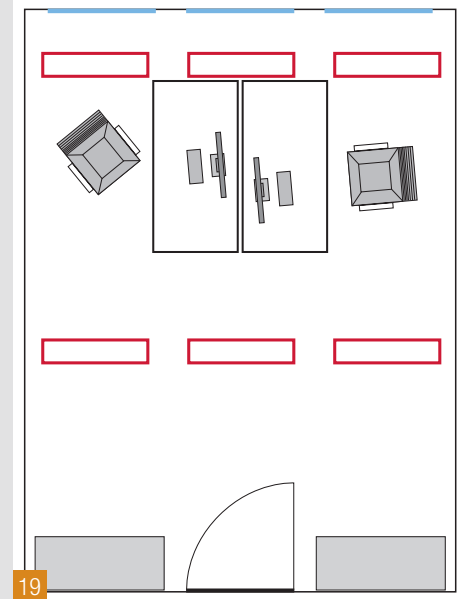
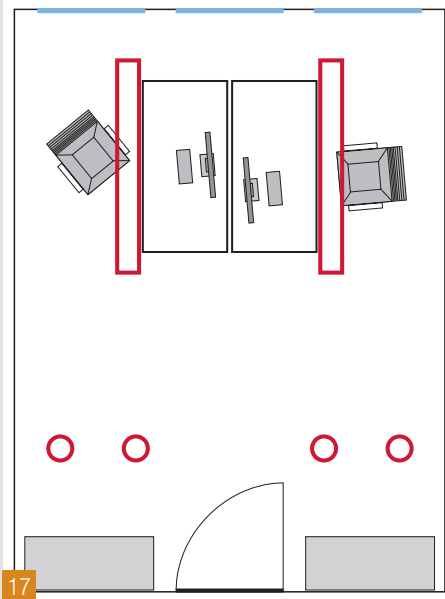
Where difficult visual tasks are performed, it is recommended that separate lighting should be provided for individual work surfaces. A typical work surface is the work area on a desktop, which can be illuminated, for example, by supplementary desk luminaires.

Standard-compliant lighting is lighting which sufficiently illuminates all task areas. For information about lighting quality features and the requirements set out in ASR A3.4 and DIN EN 12464-1, please refer to pages 32 to 37.

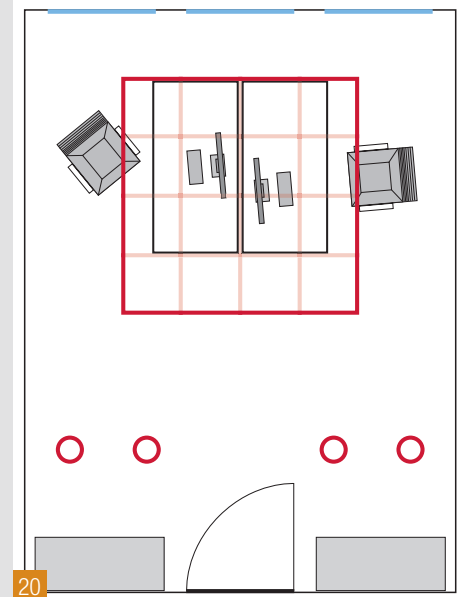
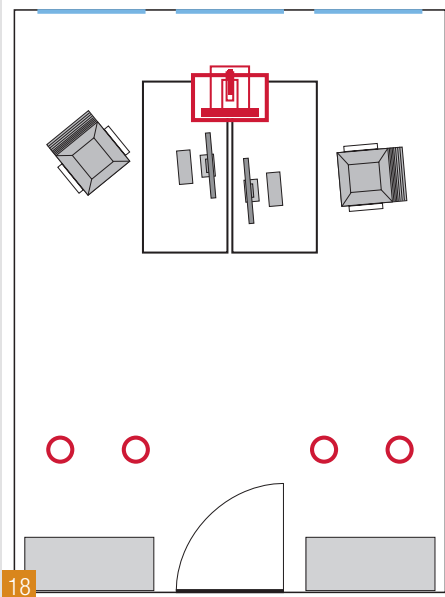


[16] Example of task area lighting: Pendant luminaires at right angles to the window wall cast light over the desk and the adjacent movement area. At the same time, the luminaires help structure the room.

[17] Plan drawing for task area lighting: Pendant luminaires are positioned at right angles to the viewing direction. The light emitted by the central section of the luminaire is entirely indirect; at the ends, it radiates directly onto the work surface from left and right. Direct glare and reflections are thus avoided. Direct/indirect luminaires with a light-controlling enclosure for the direct component are an alternative solution. The lighting concept is supplemented by downlights.



[18] Single- or double headed free-standing luminaires cast direct light onto each workplace and scatter indirect light over the ceiling. Downlights provide light in the deeper part of the room. With optionally asymmetric light distribution, they direct light onto cabinet and shelf surfaces.



[19] Task area lighting with recessed or surface-mounted ceiling luminaires or pendant luminaires installed parallel to the window wall. The workplaces are positioned between the rows of luminaires.

[20] Modular ceilings with optically active microstructures cause no glare and ensure uniform brightness throughout the room. With their large light output area, they are a highly suitable option for biologically effective lighting.

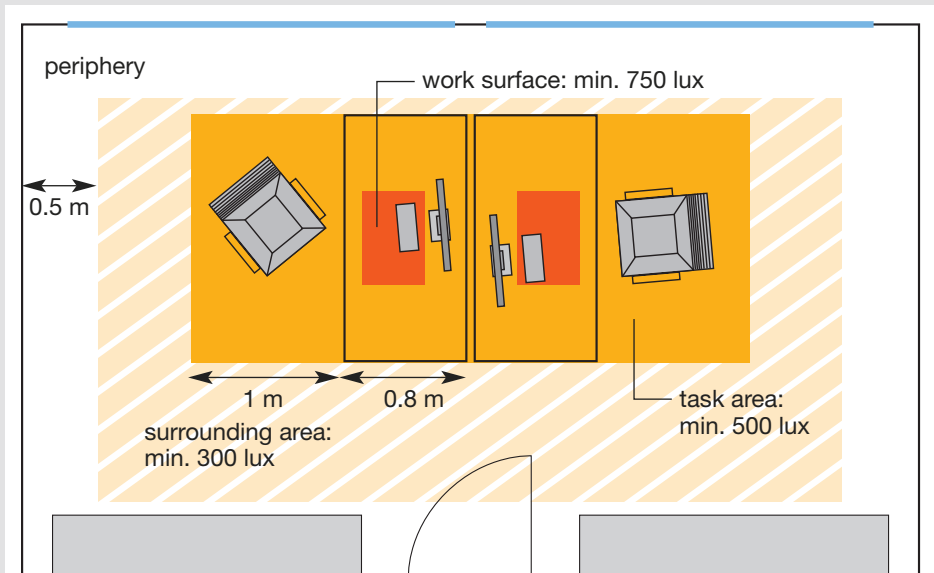
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Lighting planning

[21] An office workplace consists of work surfaces and movement area as well as the relevant floor space (shown orange in the illustration). Around it, bordered by the walls, is the immediate surrounding area. This definition meets the office workplace requirements set out in DIN EN 12464-1. For calculations, a 0.5 metre wide strip can be omitted along the walls if no task areas are located in it.

Workplaces should be illuminated to at least 500 lux; demanding visual tasks require a minimum of 750 lux on work surfaces. The lighting requirements for the immediate surrounding area are lower at a minimum of 300 lux illuminance.

Task area and surrounding area



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Impact of light on human beings

Light is not only needed for seeing. It has a major impact on our sense of wellbeing, health and performance. Modern lighting concepts recreate the dynamism of natural daylight inside a building and support employees at the workplace.

Around 80 percent of all the information that reaches our brain does so via our eyes. But light is not only vital for seeing; it is also an important synchroniser for our internal clock. Current studies confirm that many biological processes in the human body are controlled by light and the natural switch from daylight to darkness.

Light is also responsible for whether we sleep well, feel good during the day and are productive. Lack of light deprives us of the most important synchroniser for circadian rhythms (= day/night rhythms), which throws our internal clock out of kilter: the result can be fatigue, lethargy and, in the worst eventuality, depression.

Nature and natural daylight are the original synchronisers of circadian rhythms. Daylight changes over the course of the day, especially in terms of illuminance. And when illuminance is low at dawn and dusk, its colour temperature varies. Biologically effective lighting recreates these conditions and supports human circadian rhythms with different illuminance levels and dynamically changing light colours: stimulating light in the morning, bright light for high-concentration phases or a gentle transition to free time after work. Lighting systems with auto-

matically sequenced pre-set lighting moods can make a major difference in the office environment in helping to strength an employee's sense of wellbeing and ability to concentrate.

Lighting design tips

The biological impact of light is mediated by the eye but otherwise has nothing to do with vision. So a lighting installation needs to meet not only general quality criteria and energy efficiency requirements but also requirements in terms of the biological impact of light. The main parameters set by nature are:

- illuminance (vertical at the eye)
- planarity of the light
- direction of light
- light colour
- dynamism
- time of day and duration of exposure to biologically effective light.

Illumination and distribution of light

The biological impact of light increases with the visible area of the light source. So lighting concepts that involve wall and ceiling surfaces are particularly efficient. They ensure that light reaches the eye from above and from the front. Planar luminaires that can be combined to create luminous

ceilings or pendant luminaires that bounce part of their light off the ceiling and top third of the walls are recommended options for such lighting concepts. Wallwashers can also be effectively integrated.

Light colour and light sources

Light colour is an important criterion when it comes to designing biologically effective lighting. It is based on a correlated colour temperature expressed in kelvin (K) and denotes the perceived colour of a lamp's light. By comparison, the light colour of the sky varies mostly between 6,000 and 10,000 kelvin.

Daylight white light with a high blue content and a colour temperature of at least 5,300 kelvin is particularly bio-effective for day-time stimulation. Recommended light sources include fluorescent lamps with an appropriate blue content. White LEDs with colour temperatures between 6,000 and 8,000 kelvin and a spectral composition leaning towards the short wavelength (blue) end of the visible spectrum are also good sources of biologically effective light.

Because energising light is normally required only once a day, warm light colours



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(up to 3,000 kelvin) should be provided in the evening in combination with lowered illuminance.


Room environment and light colour

Where dynamic lighting is required, care must be taken to ensure that the spectral composition of the light radiated by the lamp is not altered by either the luminaire or colours in the room. In the case of luminaires, optical control elements such as louvers, enclosures and prisms can cause the biologically effective blue content of the lamp's light to be reduced.

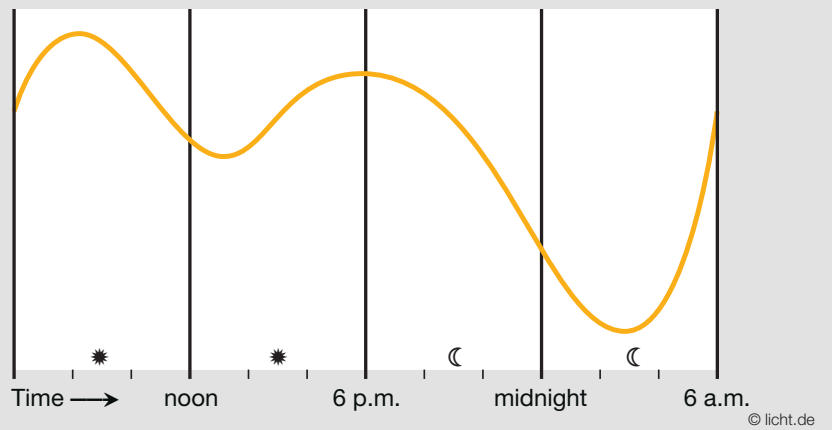
The colours of ceiling, walls and furniture can also have a major influence on the impression a room makes. Dark colours reflect less light than light ones. Wood finishes and earth colours, for instance, "swallow" a great deal of light and absorb the blue content. Bold yellows and reds are also critical colours.

Greater sense of wellbeing and more motivation

The full dynamism of daylight cannot be achieved with artificial lighting. However, plenty of scientific studies show that lighting that mimics nature heightens our sense of wellbeing and makes us more motivated.

 Further information and application examples are found in the booklet licht.wissen 19 "Impact of light on human beings".

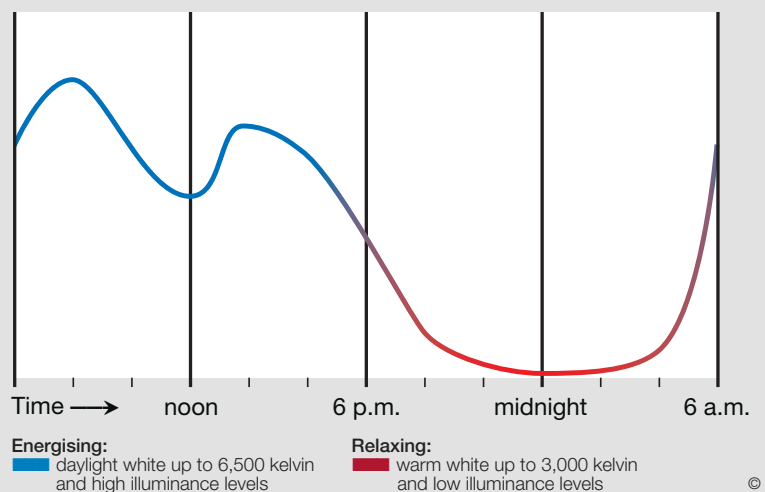
Human performance



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Biologically effective lighting



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[22 – 25] Dynamic office lighting makes for a greater sense of wellbeing, especially in areas of a room that are poorly served by daylight. Following nature's example, a dynamic lighting system makes changes in light colour, illuminance and direction of light over the course of the day. Cool light colours with a high blue content energise, warm light colour relax.

[26] The human performance curve changes over the day: body and mind are fittest at around 10 a.m. and in the late afternoon.

[27] Intelligent lighting technology supports human biological rhythms by realising pre-set lighting moods.



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Workplace lighting

From PC to phone to team meeting – in modern office life, different activities follow one another in quick succession. Good lighting ensures optimal working conditions and an agreeable room atmosphere.

Computer work in the morning, team meeting at 11 a.m., video conference with colleagues overseas in the afternoon. For many who work in offices today, that could be a normal list of diary entries. The time is gone when people spent all day at one and the same desk. The modern office worker is mobile and works where he or she is needed.

Flexible lighting solutions support employees in their work, stimulating performance and promoting a sense of wellbeing. But the design of the lighting needs to meet not only the relevant standards but also aesthetic and ergonomic criteria and personal requirements – both at the workplace and in the “open office” around it.

Visual performance and visual comfort

Good workplace lighting is always attuned to the relevant visual tasks and guarantees visual performance and visual comfort. The more difficult the visual tasks, the higher the illuminance required: for reading and

writing, 500 lux is needed to meet the minimum requirement of the standard DIN EN 12464-1 “Lighting of work places – Part 1: Indoor work places”. More light is permitted, however, and professional lighting designers generally go beyond the minimum requirements of the standard.

Glare also needs to be avoided for compliance with current standards and workplace regulations. This applies to both glare caused by daylight and glare due to luminaires. While daylight incidence is regulated by window blinds, luminaires need to be positioned and angled so that their light does not dazzle room occupants – either directly or indirectly. High-quality systems limit glare by their design. Although modern VDUs have good anti-glare finishes, care should still be taken to ensure that no disturbing reflections appear on the screen.

Open office lighting

Large office landscapes permit the flexible room layouts and zoning needed for the formation of work groups and teams. Good lighting design structures the space available and uses different lighting systems to make a visual distinction between zones.

For the general lighting, a combination of direct and indirect light is recommended. A balanced distribution of light and shade makes for an agreeable visual ambience and promotes communication. It is also rated positively by employees – especially if it can be additionally regulated to meet individual requirements. Luminaires with asymmetric light distribution (wallwashers) cast light onto walls, which then bounce it back into the room. Large luminous ceilings are also in vogue. Both solutions offer an optimal basis for biologically effective lighting.

Where ceilings are low, the illuminance required can be provided by direct luminaires with all-round glare shielding; alternatively,

[28] Pendant luminaires with direct/indirect light distribution structure the open office space and provide glare-free lighting for the workplaces. A lighting management system ensures that the luminaires are switched and dimmed according to the time of day and whether persons are present.

[29] At workplaces with large windows, optimal interaction of daylight, supplementary lighting and lighting atmosphere plays a particularly important role. Adequate glare protection and the possibility of shading windows form part of the daylighting concept.

[30] Lighting systems with good glare suppression prevent discomforting reflections on the screens.

free-standing luminaires with direct/indirect light distribution can be used.

Adjustable spots or downlights with asymmetric light distribution can be used to set accents. They direct the eye to pictures and surfaces and structure the room. Lighting control systems facilitate swift lighting replacement operations and introduce dynamism into office life.

One-person office lighting

Direct/indirect light distribution is the right solution for one-person offices and “work spaces”. Pendant or free-standing luminaires directly at the workplace fulfil the requirements. At work zones near windows, it is important to ensure an optimal interplay of daylight, artificial light and lighting atmos-

phere. Luminaires are often installed parallel to the window wall to supplement daylight incidence.

Flexible lighting

Desk or free-standing luminaires give employees access to supplementary lighting if required. This makes work easier on the eyes and guards against early fatigue. Desk luminaires are also suitable where the desk allows the user to switch from a seated to a standing position.

The use of lighting management systems is always recommended. They control and regulate the lighting according to requirements, presence, time of day and season. They thus enhance the convenience of the lighting and also lower energy costs.

[31 + 35] Lighting management systems permit separate switching and dimming of lights according to presence, time of day and the lighting atmosphere required. Intelligent systems enhance convenience and reduce the energy requirement of the enterprise.

[33] A pendant luminaire with pronounced indirect components ensures uniform lighting in the one-person office and makes the room feel bright. Louvers direct the direct light onto the work surface without causing glare.

[34] Desk luminaires provide supplementary light.



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VDU work

Modern office monitors [32] generally have a good anti-glare finish. They can even handle relatively high luminance up to 1,500 cd/m². Nevertheless, the design of lighting for VDU workplaces must take account of the fact that disturbing glare, mirroring and reflections on screens need to be avoided.

Accordingly, luminaires should reduce the luminance of the lamps used and windows should be fitted with adjustable blinds. A balanced distribution of brightness is important between screen and work environment.



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Communication zone lighting

Cooperation and exchange of ideas are the drivers of the creative knowledge society. The “living space office” offers communication zones that are equally suitable for concentrated teamwork or relaxation.

Communication is a major productivity factor in the knowledge society; teamwork and networking play an important role in modern working life. And who would claim that big ideas are never born during a chat with colleagues at the espresso bar?

Experts estimate that around 80 percent of all innovations originate as a result of face-to-face communication. This is why more and more employers actively encourage communication between employees by providing appropriate conversation zones. They currently account for around 30 percent of office space – and the figure will rise in the future. This not only has implications for office planning; it also needs to be taken into account by the lighting designer. In harmony with architecture and furnishings, lighting design needs to deliver light that is both emotionally appealing and functional for a comfortable conversation. Dynamic lighting solutions ensure that lighting stimulates communication, boosts creativity or promotes relaxation.

Lighting comfort for conversations

Direct/indirect lighting solutions offer appropriate light with high visual comfort for conversations and reading. For reading, the preference is generally for a predominantly direct lighting component beside the seat; for conversations, indirect lighting makes for an agreeable atmosphere and casts faces in a kinder light. Free standing luminaires permit flexible lighting and furnishing arrangements. Formally coordinated design concepts can be flexibly adapted for different purposes by a lighting management system.

In restaurant areas or small cafeterias, correct lighting also ensures that relaxation and wellbeing are made possible even during short breaks from work. Glare-free lighting at tables is provided by downlights or decorative pendant luminaires; lamps with good colour rendering characteristics are essential.

Differentiated lighting supports zoning in a room. LED light from cornices, for example,

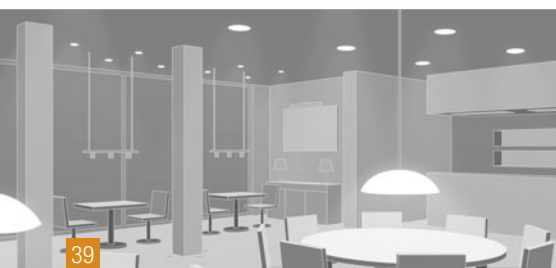
or diffuse opal back-lit glass light panels on ceiling, walls or counter create a sense of space; spots sets accents in the room. In all communication and catering areas, good glare suppression is definitely important.

[36] Efficient, long-lived and as attractive as the interior design: recessed LED luminaires and a pendant LED luminaire cast the meeting area in dramatic light.

[37] Large-area surface-mounted luminaires provide agreeable light for brief meetings. Optically active microstructures in the luminaire make for homogeneous lighting.

[38] In the aisle zone, seating cubes create inviting areas for a casual chat with colleagues. Downlights mark the route.

[40] Round recessed luminaires blend well with the architecture and create a comfortable lighting atmosphere at the table.



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Table lighting

In catering zones, [39] pleasantly bright lighting with balanced direct and indirect components is the recipe for an atmosphere conducive to relaxation, recreation and communication. DIN EN 12464-1 recommends a minimum illuminance of 200 lux. Pendant luminaires are ideal for illuminating tables. They should be suspended around 60 centimetres above the table top – i.e. just above eye-level – and should not dazzle diners.



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Conference and training room lighting

Seminars, round-table discussions, lectures – conference and training rooms are communication hubs, equipped with the latest media technology. Their multifunctional character means they require lighting that is flexible, attractive and efficient.

Flexibility is trumps – not only in the “open office” but also – indeed especially – in conference rooms, which remain an essential hub of communication. This is where colleagues come together for workshops, where clients are received and where crucial decisions are made for new projects.

Conference rooms present the enterprise and its culture. They are equipped with multimedia technology and designed to provide a stimulating atmosphere that is equally suitable for animated debate and focused work. One room, lots of purposes – which means the lighting technology installed needs to be a peak performer. It has to provide the right lighting scenario for every kind of room use.

Light defines room atmosphere

The right mix of lighting systems guarantees flexible lighting. Ceiling luminaires ensure background brightness, floods and spots set accents.

Homogeneous glare-free light is the right choice for the general lighting. An open atmosphere is created by lighting systems designed for direct/indirect light distribution. The indirect component brightens the ceiling and ensures visual comfort for seminars and meetings.

If a more secluded atmosphere is required, e.g. for important meetings or discussions, accentuating light delivering sufficient illuminance to horizontal surfaces is recommended.

Floods and spotlights illuminating wall areas or art objects and different light colours enliven the room. Coloured cornice lighting or light dots – based in LED technology – set eye catching accents.

Presentation lighting


Flexible lighting is particularly important for presentations. Downlights and spots deliv-

ering accentuating light can provide the vertical lighting needed to cast speakers in the right light at the lectern or on stage. Near the media wall, separately switched supplementary lighting should be provided to ensure good visual conditions for presentation boards and flipcharts.

For video and beamer presentations, however, the media wall needs to be fully darkened, while the background lighting should provide enough light for orientation and note-taking. Dimmed accent lighting on side walls helps prevent visual fatigue, which can easily occur in a darkened room.

Systematic lighting management

The wide range of lighting tasks performed in a conference room calls for a sophisticated lighting control system. Such systems offer the convenience of activating and customising programmed lighting scenes by remote control. Some also enable window blinds to be adjusted as required.

 More information on this application can be found in the booklet licht.wissen 02 “Good Lighting for a Better Learning Environment”.



Lighting for lectures

Presentation areas [42] should be illuminated for a lecture to at least 1.5 times the average illuminance in the room. 500 lux in the conference room means 750 lux on the horizontal surfaces of the lecture area, which also requires a good level of vertical illuminance. Lighting management systems enhance the convenience of lighting control. Pre-set lighting scenes can then be quickly called up from a control panel near the speaker, e.g. dimmed light for video presentations.

[41] Light modules create an open atmosphere in the conference room. Supplementary downlights near the edge of the ceiling provide sufficient background brightness for beamer-based presentations without generating scattered light. Dimmed accent lighting helps prevent fatigue and enables those listening to take notes.

Lighting management – more quality and efficiency

Tailored to requirements and ergonomically correct, extremely convenient and energy-efficient – lighting management technologies make office lighting flexible. They ensure that the right light is available in the right quantity at the right time and place.

The right light helps us perform visual tasks, creates atmosphere and promotes a sense of wellbeing. Conventional static lighting installations – which are still found in two thirds of German office buildings – no longer meet these requirements. In some cases, for example, lights in empty offices and corridors stay on 24 hours a day. That is a waste of energy and a cause of high costs.

Lighting management systems break the rigid mould of on/off operation. Sensors control the lighting for indoor and outdoor areas – and regulate the light as required.

The building blocks of a lighting management system include:

- retrievable lighting scenes for different activities: programmed settings may be identified, for example, as “desk”, “presentation” or “meeting”.
- lighting control based on motion detectors: they ensure that lights are activated only when a person is present in the room (presence control).
- lighting level regulation by dimming and/or partial deactivation, depending on incident daylight.

Daylight and artificial lighting

Changes in brightness in the work environment enliven the room. Because the human

nervous system is primed for variety, they heighten alertness and promote a sense of wellbeing. The ideal situation is achieved through maximum utilisation of daylight, as is, in fact, required by German workplace regulation ASR A3.4. Dedicated daylighting systems even direct natural daylight into remote room zones. Intelligent lighting control also enables dynamic artificial lighting to be realised in imitation of daylight. Changes in illuminance and light colour motivate employees and enhance employee performance, especially in parts of rooms where daylight incidence is low. Concentration, for example, is promoted by daylight white light.

Solutions can be realised for individual luminaires, rooms or entire buildings, depending on the intended purpose. Intelligent systems offer four major advantages:

- easy adjustment of lighting to cater for different activities and individual lighting requirements
- energy and cost savings through presence control and daylight utilisation
- dynamic lighting control based on time of day and season for a greater sense of wellbeing
- high flexibility.

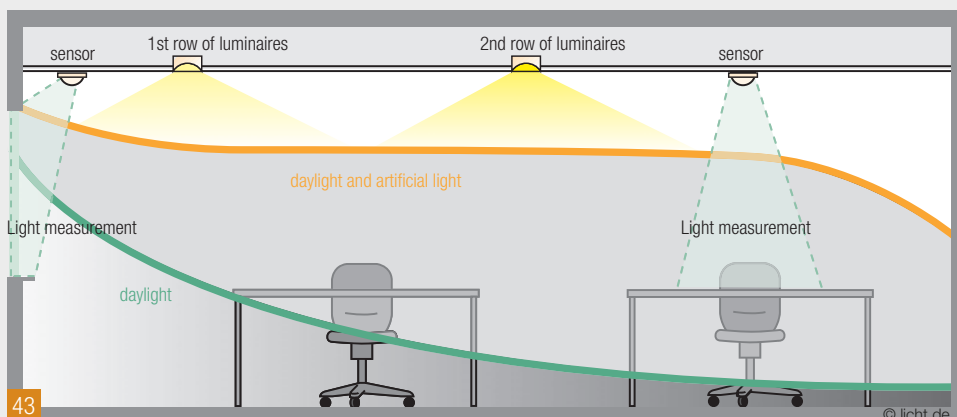
Flexibility is a major asset in office buildings, especially in investment properties. Nearly a

third of all workplaces are altered or remodelled each year, most of them while work operations are still going on. Where luminaires are governed by a control system, lighting can quickly be adapted to the new room layout.

DALI and KNX

Lighting management systems can only be used with luminaires that work with dimmable electronic ballasts. One good solution is to use either DALI (Digital Addressable Lighting Interface) or DALI/KNX gateways. The DALI interface permits individual control of a large number of luminaires with a small number of cables – even over great distances. DALI can also be integrated in higher-level building management systems such as KNX.

Once the relevant lighting management system is installed, the technology works in the background. Occupants can activate their own settings by mouse-click and modify their workplace lighting as required. All it takes is a laptop and a few seconds to log on. It is not even necessary to be at the workplace.



[43] Daylight-dependent lighting control saves energy. It enables artificial lighting to be switched and dimmed as required. Light sensors in the room or directly at the window monitor the amount of light available and adjust the lighting level according to daylight incidence.

[44 + 45] Lighting management systems make for greater convenience and help save energy: brightness is automatically adjusted according to presence and daylight incidence. So the artificial lighting provided is no more than is actually needed.

[46] Pre-programmed lighting moods can be easily activated from a control panel or remote control device.



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Foyer and corridor lighting

The entrance area is the calling card of the host. This is where first impressions are made. Emotive interior and lighting design conveys a sense of openness and acts as a vehicle for corporate culture.

The foyer plays an important role not only in large office buildings but also in smaller business premises. It defines the character of the property, welcomes visitors and promotes personal contact. Attractive lighting design, good colour rendering, brilliant light and a varied landscape of vertical and horizontal illuminance enhances visual comfort.

Bright glare-free lighting helps visitors entering the building during the day to get their bearings. Large windows, back-lit ceiling panels or indirect wall luminaires create zones of bright light and create a sense of optical depth. Attractive supplementary accent lighting prevents the room from making a monotonous impression. This is achieved, for example, with a combination of diffuse light lines and spots, which can be flush-mounted in ceilings.

Entrance area lighting

Entrance lighting needs to be designed to provide guidance: the entrance itself, the

reception with waiting area and routes to staircases, corridors and other parts of the building require a differentiated lighting design. Direct/indirect lighting with warm white light makes for balanced brightness and a positive atmosphere for conversation. Translucent fronts on reception desks – e.g. efficiently back-lit by LED modules – look attractive. LED lighting solutions make it easy to harness the agreeable effects of colour and dynamic light in a foyer.

Corridor and aisle lighting

Corridors and aisles provide swift access to different parts of a building. Illuminated walls give a sense of security and make the room look more spacious. Corridors that seem endlessly long can be divided effectively into sections by interesting lighting design and accent lighting, e.g. illuminating pictures on the walls.

Communication route lighting can also be dynamically adapted according to the sea-

[47] Two stately towers clad in back-lit textile sheeting form a central eye-catcher in the atrium. Routes are accentuated by filigree light lines under parapets and staircases.

[48] A large luminous ceiling underlines the architecture of the foyer. The direct light of recessed downlights marks peripheral zones, which are additionally illuminated by cornice lights.



son and time of day. In areas poorly served by daylight, for instance, LEDs with a wide range of colour temperatures can be used to imitate the natural course of daylight. Inviting light also promotes communication in rest areas in aisles. Supplementary recessed floor and wall luminaires indicate the route, marking lift areas and meeting points. Where recessed floor luminaires are used, care needs to be taken to ensure that they do not dazzle.

[49] A communication zone with added value: work islands are installed on the wide staircase. Luminaires with wide-angled intensity distribution curves make for safety on the stairs.

[50] Pendant luminaires with direct/indirect light distribution create an agreeable atmosphere in the long corridor.

[51] Skylights admit daylight for the corridor during the day. LED downlights provide light in the evening.

[52] LED downlights guide visitors through the building to the lifts.

Corridors and staircases are also escape routes, so they need to be equipped with appropriate safety lighting.

Safe ascent

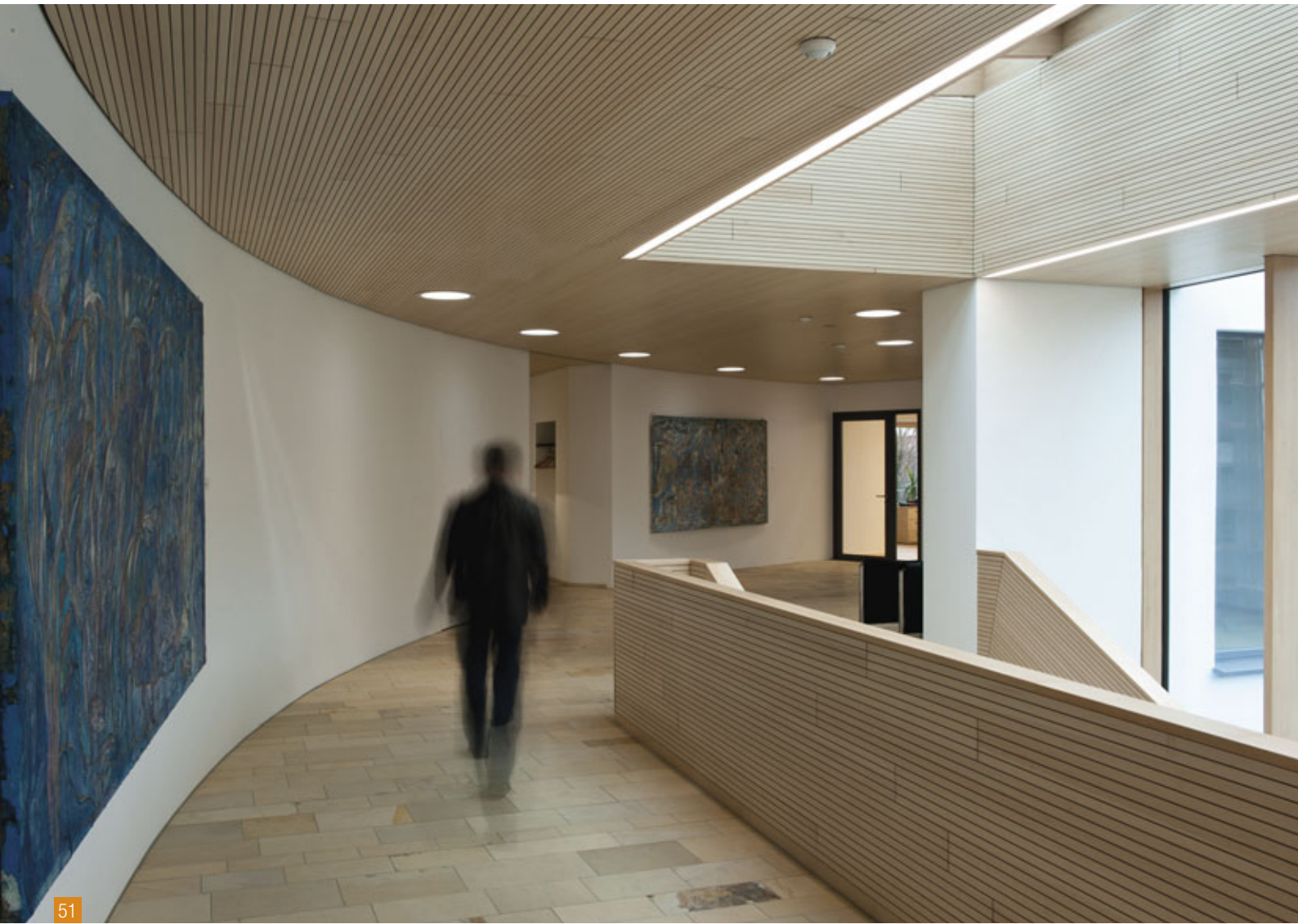
Staircases are often a prestigious feature of a building. But first and foremost they need to be safe for anyone using them. Light falling downwards from the top landing makes for short, soft shadows. Stair treads are thus clearly distinguished, every

single stair is readily identifiable. Luminaires with a wide-angle intensity distribution curve installed parallel to the stairs are a good choice. It is also often useful to mark stairs with orientation lights. The can be recessed in the wall or, for wide staircases, set directly into the treads. Depending on the luminaire model used, every stair needs to be illuminated, every third stair at least.

Lighting management is a worthwhile investment

A lighting management system pays for itself even in relatively small office suites because a great deal of the energy consumed in buildings goes on light for corridors, foyers, toilets and offices that are often empty. Intelligent lighting control systems ensure that lighting is only activated when it is actually needed. LEDs are a solution for the future here because their life is not shortened by frequent switching and dimming.





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Communication routes and lifts

Guiding lights: corridors, staircases and lifts take employees and visitors deeper into the building. The right varied light plays a crucial role in helping to make the route attractive and to avoid “tunnel effects” in long corridors without daylight. Lighting for such corridors should provide illuminance levels similar to or only slightly lower than those in the entrance area. DIN EN 12464-1 sets out a minimum of 100 lux illuminance for corridors and stairs.

Because lots of people feel uncomfortable when they enter a lift, the area around the lift entrance should be significantly more brightly lit for reassurance. The lighting can be realised, for instance, with wall luminaires mounted on the left and right of the lift doors. Additional guidance at the entrance is provided by recessed floor luminaires. Inside the lift, light ground colours are recommended. Like mirrors and reflective ceilings, they give the suggestion of more space. A lighting installation with pronounced diffuse lighting components prevents unpleasant shadowing on faces.



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Lighting quality and standards

Every good lighting design focuses on human needs. Light should motivate us and keep us healthy. For employers and investors, the efficiency and flexibility of a lighting installation are equally important factors. Optimal lighting installations comply with the relevant standards. They are sustainable and meet ergonomic, environmental and economic requirements.

At the desk, on the way to a conference or in the training room – good lighting ensures a pleasant luminous environment in office or administrative premises. It supports us in our various visual tasks and facilitates fatigue-free work.

The basic requirements that need to be met by lighting for work premises in office buildings are found in DIN EN 12464-1 "Light and lighting – Lighting of work places – Part 1: Indoor work places", which was updated in 2011 and applies across the whole of Europe. In Germany, workplace regulation ASR A3.4 "Lighting", which was revised in April 2011, also needs to be observed. The ASR concretises the health and safety requirements that need to be met for employees at work. Outdoor workplace lighting is covered by DIN EN 12464-2 "Light and lighting – Lighting of work places – Part 2: Outdoor work places".

For non-residential buildings, an Energy Performance Certificate needs to be issued in line with the Energy Saving Ordinance (EnEV). The methods for calculating the energy required for lighting are set out in the pre-standard DIN V 18599-4 "Energy efficiency of buildings – Calculation of the net, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting – Part 4: Net and final energy demand for lighting".

Lighting quality features

ASR A3.4 stipulates that, work premises need to be sufficiently served by daylight and furnished with appropriate artificial lighting. A good lighting installation takes account of the visual, emotional and biological impacts of light – and is energy efficient. For compliance with DIN EN 12464-1, however, there must be no compromise on lighting quality for the sake of lower energy consumption.

Lighting quality is expressed through quality features. It can be achieved by natural or artificial light or by a combination of the two. Important features include:

- illuminance
- luminance/brightness distribution
- limitation of direct and reflected glare
- direction of light and modelling
- light colour and colour rendering
- freedom from flicker
- possibility of changing lighting level and light colour

Illuminance

Illuminance has a major impact on how swiftly, reliably and comfortably our eyes can carry out a visual task such as reading or working at a PC. Measured in lux (lx), it is the luminous flux that falls on a given area from a light source. For writing and reading, PC work and conferences, DIN EN 12464-1 requires a minimum of 500 lux illuminance on horizontal work surfaces such as desk-tops. At the same time, the more difficult the visual task, the higher the illuminance needs to be. The guideline values recommended in the standard are listed on page 37.

DIN EN 12464-1 indicates the maintained illuminance values that apply in normal visual conditions. Many people, however, prefer higher illuminance levels – which is hardly surprising given that when we are indoors we often have to make do with far less light than daylight. In sunshine on a cloudless day, illuminance can reach 100,000 lux, and even on a cloudy day it can be as high as 20,000 lux. So in winter especially, when days are dull, higher illuminance is welcome and helps prevent fatigue.

Illuminance on walls, ceilings and in the room

Attention needs to be paid to the perceived brightness of the room as a whole. This is

why the standard sets out minimum values for illuminance on walls and ceilings. Cylindrical illuminance is taken as the yardstick for perceived brightness, which depends crucially on vertical illuminance. It is used, in particular, to assess how well faces can be recognised.

Good visual communication occurs only where objects and faces can be easily and quickly recognised. So in rooms in which people move around and work, the standard requires an average cylindrical illuminance of at least 50 lux. In zones where good visual communication is particularly important, e.g. in an office or conference room, the average cylindrical illuminance should not fall below 150 lux. ASR A3.4 requires 175 lux vertical illuminance from the main viewing direction. As a general rule, a third of the horizontal illuminance is a good recommendation.

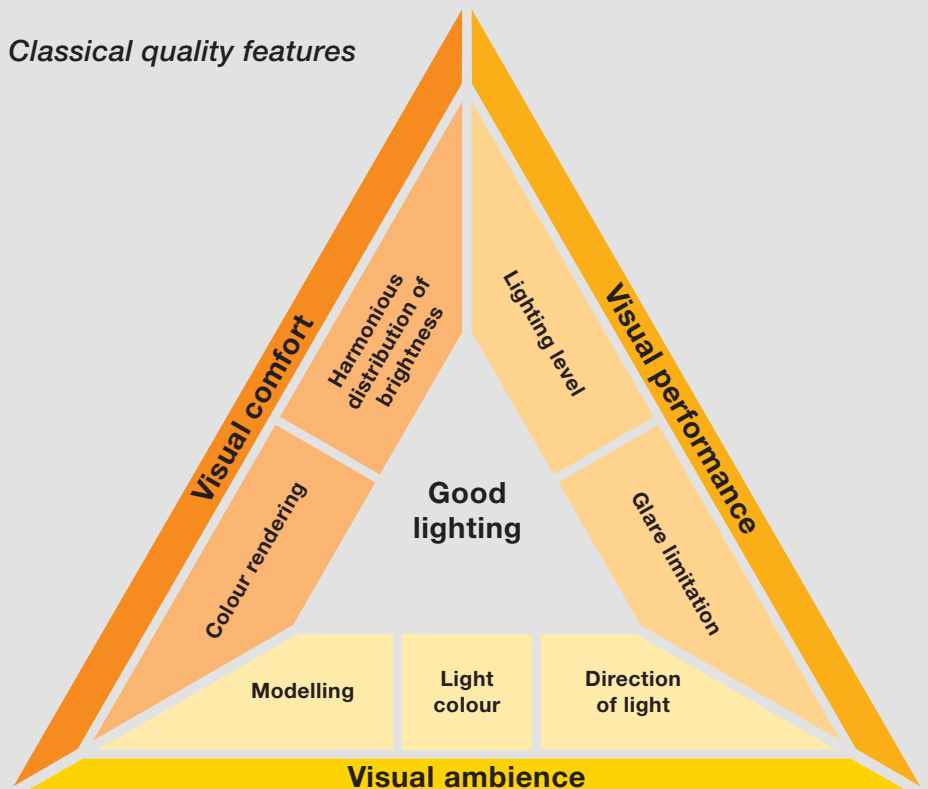
Uniform brightness and luminance

An office worker's gaze switches frequently between desk or computer table and room zones farther away. Excessive differences in brightness force the eye to adapt over and over again, which gives rise to fatigue and interferes with our sense of wellbeing. Just as disagreeable as marked contrasts, however, are inadequate differences in illuminance, which quickly make a room seem monotonous.



Lighting quality features

Classical quality features



Other quality features

Daylight integration	Energy efficiency
Variable lighting situation	Individual adjustment

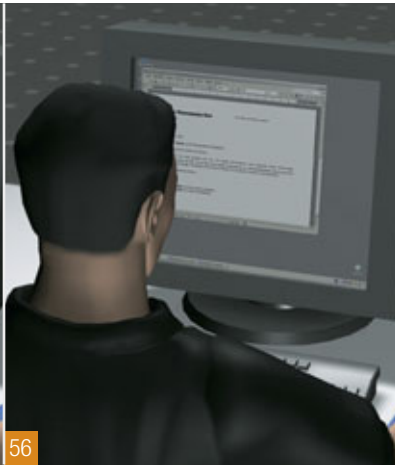
[53] The visual tasks performed at the workplace determine the requirements that lighting needs to meet. It also needs to be efficient and should create a pleasant atmosphere.

[54] Standards and workplace regulations identify quality features that together determine the quality of a lighting installation. They need to be considered at the planning stage.

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The solution is a harmoniously balanced distribution of brightness in which visual objects stand out from the background because of their luminance (symbol: L). Luminance is the brightness of a luminous or illuminated surface as perceived by the human eye. It is measured in candela per square metre (cd/m²). It needs to be borne in mind here that light-coloured surfaces reflect a great deal more light than dark ones.

So in rooms with high visual communication requirements, walls need to be illuminated to at least 75 lux and ceilings to at least 50 lux for compliance with the current DIN EN 12464-1 standard. These minimum values were incorporated in the norm when it was updated in 2011. In both cases, higher illuminance is better because it enhances visual comfort.

The illuminance on a surface needs to be provided with a certain degree of uniformity (= U₀). U₀ is the ratio of the minimum to average illuminance on a surface (see also the table on page 37).

Light for surroundings and background

It is important to ensure sufficient lighting for the immediate surrounding area of a workplace, especially if the room is not well served by daylight. Switching between brightness levels in the room places a considerable strain on the eyes. The immediate surrounding area should therefore be uniformly illuminated to a sufficiently high level.

Illuminance in the immediate surrounding area – generally the area extending to the next movement area or wall – can be lower than in the task area. However, it must not fall below certain standard values (see table of this page). Care must be taken to ensure an illuminance uniformity of U₀ ≥ 0.40.

In very large offices – and only there – a background area is defined beyond the movement areas. For it, the standard requires a maintained illuminance no less than a third as high as in the immediate surrounding area as well as illuminance uniformity of U₀ ≥ 0.10.

Observance of maintained illuminance requirements

As time passes, luminaires, lamps and room surfaces age and become soiled, so illuminance diminishes. To allow for this, lighting installations need to be designed on the basis of maintained illuminance values. Maintained illuminance (E_m) is the value below which average illuminance must not fall regardless of the age or condition of the lighting installation. New installations are thus designed for higher illuminance (= illuminance on installation). Maintenance intervals are defined in a maintenance schedule, which must be prepared by the lighting designer.

Avoidance of glare

Glare considerably impairs visual performance and prolonged exposure to it gives rise to fatigue and loss of concentration. So glare should always be avoided. There are two types of glare:

- direct glare
- reflected glare.

Direct glare occurs as a result of excessively high luminance, e.g. due to inappro-

Task illuminance E _{task} /in lux	Illuminance of immediate surrounding areas lux
≥ 750	500
500	300
300	200
200	150
150	E _{task}
100	E _{task}
≤ 50	E _{task}



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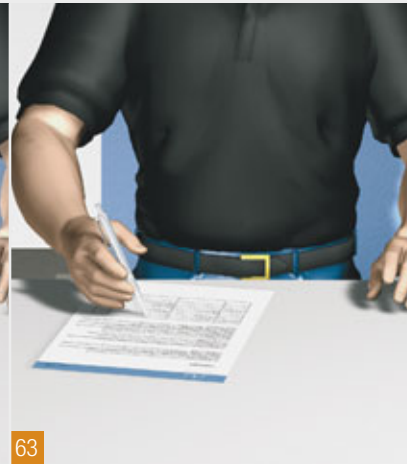
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[55 + 56] Reflected glare on the screen due to unshielded luminaires, sunlight or reflections impairs visual performance and needs to be avoided.

[57 + 58] Reflected glare also interferes with the legibility of literature and documents printed on glossy paper. Luminaires with direct/indirect lighting components, correct positioning of light sources in the room, adequate anti-glare screening at windows and a correct arrangement of workplaces help significantly reduce reflected glare.

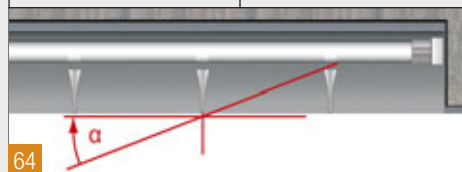
[59] The unified glare rating [UGR] method takes account of all the luminaires in a lighting installation that could cause a sensation of glare. It also factors wall and ceiling brightness into the rating.

[60 + 61] The colour rendering characteristic of a lamp indicates how naturally it renders colours in the room. Lamps may have different colour rendering properties even if their light colour is the same. Where the spectrum of a lamp contains little red light, for example, red surface colours are imperfectly rendered.

[62 + 63] Unfavourable light distribution: for a right-handed person, light should fall on the desk from top left to prevent shadows obscuring the text at the point of writing (for left-handed persons from top right).

appropriate, wrongly positioned luminaires, unshielded light sources or even inadequately shaded windows that let sunlight into the room. To avoid glare caused by bright light sources, lamps should be shielded. Minimum shielding angles need to be observed for the following lamp luminances:

Lamp luminance cd/m^2	Minimum shielding angle α
20,000 to < 50,000	15°
50,000 to < 500,000	20°
$\leq 500,000$	30°



Direct glare is rated by the UGR (Unified Glare Rating) method. Every luminaire in the lighting installation that could contribute to a sensation of glare as well as the brightness of walls and ceilings are taken into consideration.

Reflected glare occurs as a result of reflections on shiny surfaces such as computer screens.

Both types of glare have a similar effect. In particular, they impair contrast perception and degrade visual conditions. DIN EN 12464-1 sets out minimum glare limitation values for the main types of interior in office buildings.

Direct and reflected glare can be avoided or effectively reduced by the following measures:

- correct arrangement of workplaces in relation to luminaires, windows and skylights
- adequate anti-glare screening at windows and skylights

- use of well-shielded luminaires in a correct arrangement
- room furnishings with preferably matt light-coloured surfaces
- light-coloured ceiling and walls

VDU workplaces

The levels of luminance that can cause mirroring and reflections on screens depend on the reflective properties of the screens used. Modern VDU technology with high background luminance and good glare suppression permit significantly higher luminance limits, which have been taken into account in the current standard.

For compliance with DIN EN 12464-1, VDU workplace lighting needs to be designed so that it caters for all the visual tasks performed at the workplace. Modern screens with luminances of $\geq 200 \text{ cd/m}^2$ can even handle relatively high luminances up to $3,000 \text{ cd/m}^2$. However, designers should still choose types and arrangements of luminaires that will not give rise to annoying reflections. The luminance limit for normal screen settings is $1,500 \text{ cd/m}^2$ above an elevation angle c of 65° . Screens with a high-gloss surface are critical, however, because even a white shirt reflects in them. They should not be used in offices.

Offices with VDU workplaces require adjustable anti-glare screening at windows.

Modelling and shadows

Objects acquire visual depth only where light and shade are properly balanced. Distances can then be accurately gauged and orientation is facilitated.

Balanced soft-edged shadows guarantee good visual conditions. The ratio between cylindrical and horizontal illuminance is

known as modelling and is an important quality feature.

Where people, room architecture and furnishings are illuminated so that shapes and surface structures are clearly recognisable, the luminous environment of the workplace becomes agreeable. The best results are obtained with a mixture of directional light and diffuse indirect light. So workplace lighting should not consist exclusively of individual small light sources because each of them produces a visible shadow. Conversely, indirect light distribution alone does not create enough shadows for 3D vision. What is more, diffuse lighting with undefined shadows creates a monotonous luminous environment.

Light colour and colour rendering

Light colour is the intrinsic colour of a lamp's light. It is expressed as a correlated colour temperature in kelvin (K). White light is divided into three basic categories: warm white (< 3,300 K), neutral white (3,300 – 5,300 K) and daylight white (> 5,300 K) light. Light colours influence our mood: warm white light colours have a soothing effect, cool light colours are more energising.

The colour rendering characteristic of a lamp is another important factor for good office lighting. It determines how naturally colours in the room are rendered by the lamp's light. So colour rendering affects whether colour samples, for example, can be properly assessed. And if a colleague looks pale and sallow, it is not necessarily because of a cool light colour; it could be

that he is sitting under a lamp with a poor colour rendering characteristic.

The colour rendering quality of a lamp is indicated by its colour rendering index. The highest possible rating is $R_a = 100$. All lamps for office applications today have the required good colour rendering index of $R_a > 80$.

Freedom from flicker

Flickering or pulsating light impairs vision and needs to be avoided. It may lead to fatigue and headaches or to accidents (e.g. due to stroboscopic effects). Electronic ballasts are standard technology today. They help reduce energy requirements and avoid fluorescent lamp flicker.

Energy efficiency and daylight


Energy efficiency is another aspect that needs to be considered when designing a lighting installation. While DIN EN 12464-1 underlines the importance of not compromising "the visual aspects of a lighting installation simply to reduce energy consumption", the requirements of the relevant lighting task should be met with the least possible waste of energy. Options for maximizing energy efficiency include harnessing daylight, selecting highly efficient ballast/light source systems, using luminaires with a high light output ratio and creating a low-maintenance lighting installation with long life components.

"Intelligent" control systems ensure that daylight is supplemented by just enough artificial light to produce the illuminance needed at the workplace. Each person in

the room should be able to adjust the light to his or her own personal requirements.

Utilisation of daylight is not only recommended to save energy; it is actually mandatory for compliance with ASR A3.4. Light impacts on our mood, emotions and performance. The illuminance and light colour of natural light change dynamically over the course of the day and support our biological rhythms even while we are at work. Hence the fact that DIN EN 12464-1 lists variability of light as a quality feature of lighting installations. In conjunction with daylight or with appropriately designed artificial lighting, adjustable lighting levels and light colours can bring the dynamism of daylight to the workplace. Lighting management systems are essential for this.

Lighting management systems enable light colours, colour effects and illuminance to be precisely controlled and regulated to create a lighting atmosphere at the workplace that accurately replicates the natural course of daylight. At the same time, it offers optimal light for the varying requirements of the visual tasks performed and the personal needs of individual office workers. It thus boosts motivation and makes for a greater sense of wellbeing.

 More information about the medium of light is found in the booklet licht.wissen 01 "Lighting with Artificial Light". The various ways in which light supports human biorhythms are covered in the chapter "Impact of light on human beings" on page 16 of this booklet.

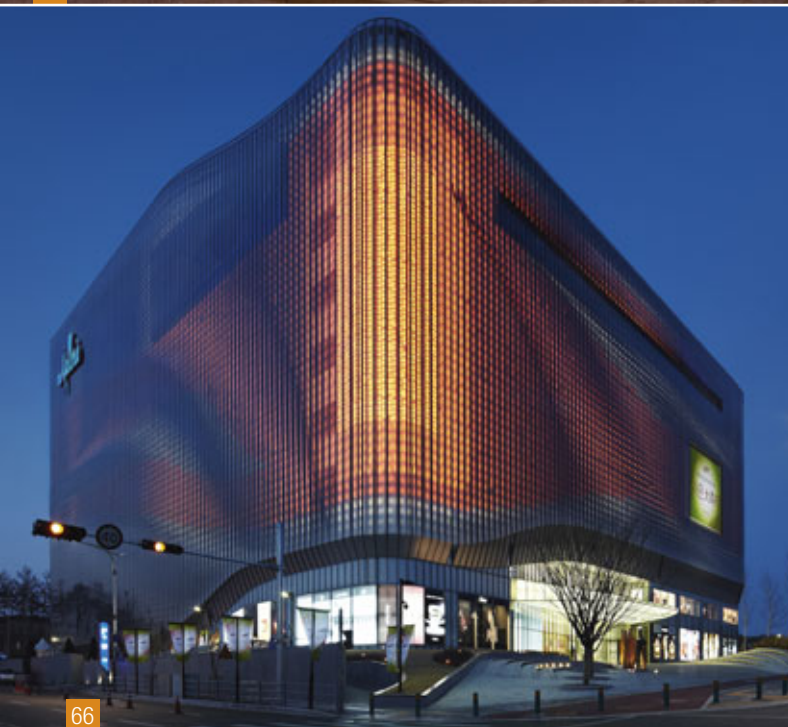
Minimum lighting requirements recommended by DIN EN 12464

Type of interior, task or activity	Illuminance on visual task plane \bar{E}_m / lx	UGR _L	U ₀	R _a	Remarks
Office work					
Filing, copying	300	19	0.4	80	
Writing, typewriting	500	19	0.6	80	DSE work governed by further requirements in DIN EN 12464-1, see 4.9
Reading, data processing					
Technical drawing	750	16	0.7	80	
CAD workplaces	500	19	0.6	80	DSE work governed by further requirements in DIN EN 12464-1, see 4.9
Conference and meeting rooms	500	19	0.6	80	Lighting should be controllable
Reception desk	300	22	0.6	80	
Archives	200	25	0.4	80	
Public areas					
Entrance halls	100	22	0.4	80	UGR only where applicable
Cloakrooms	200	25	0.4	80	
Waiting rooms	200	22	0.4	80	
Cash desks and service points	300	22	0.6	80	
Traffic zones in buildings					
Communication areas and corridors	100	28	0.4	40	<ul style="list-style-type: none"> ▪ Illuminance at floor level ▪ R_a and UGR similar to adjacent areas ▪ 150 lx if there are vehicles on the route ▪ Transition zone for entrances and exits ▪ Avoid glare for motorists and pedestrians
Staircases, escalators, travelators	100	25	0.4	40	Requires heightened contrasts on treads
Lifts	100	25	0.4	40	Illuminance in front of the lift min. $\bar{E}_m = 200$ lx
Loading ramps/bays	150	25	0.4	40	
Ancillary rooms					
Canteens, pantries	200	22	0.4	80	
Kitchens	500	22	0.6	80	
Rest rooms	100	22	0.4	80	
Rooms for physical exercise	300	22	0.4	80	
Changing rooms, washrooms, toilets, bathrooms	200	25	0.4	80	In each individual toilet if totally enclosed
Sanitation rooms	500	19	0.6	80	
Rooms for medical attention	500	16	0.6	90	4,000 K ≤ T _{CP} ≤ 5,000 K
Plant rooms, switch gear rooms	200	25	0.4	60	
Post rooms, switchboard	500	19	0.6	80	
Store and stockrooms	100	25	0.4	60	200 lx, where permanently manned
Dispatch packing handling areas	300	25	0.6	60	
Öffentliche Parkgaragen					
– Traffic lanes	75	25	0.4	40	<ol style="list-style-type: none"> 1. Illuminance at floor level 2. Safety colours shall be recognisable
– Parking areas	75	–	0.4	40	<ol style="list-style-type: none"> 1. Illuminance at floor level 2. Safety colours shall be recognisable 3. High vertical illuminance improves recognition of faces and sense of security
– In/out ramps (at night)	75	25	0.4	40	<ol style="list-style-type: none"> 1. Illuminance at floor level 2. Safety colours shall be recognisable
– In/out ramps (during the day)	300	25	0.4	40	<ol style="list-style-type: none"> 1. Illuminance at floor level 2. Safety colours shall be recognisable
– Ticket office	300	19	0.6	80	<ol style="list-style-type: none"> 1. Avoid reflections in the windows 2. Avoid glare from outside

Notes on the tables:

\bar{E}_m = maintained illuminance in lux (lx)
 UGR_L = UGR limit, limitation of direct glare
 U₀ = uniformity of illuminance

R_a = colour rendering index of the light source
 T_{CP} = correlated colour temperature



Facade lighting

The visual impact of a building is a key element of corporate culture. In the evening, light emphasizes architecture, communicates brand identity and attracts attention – effectively and efficiently.

Modern office buildings shape the face of large areas of the urban environment. Their facades are perfect for effective lighting – lighting that can either emphasize key elements of the facade or be cleverly designed to create a totally new effect.

Lighting – as the “fourth dimension” of architecture – sets accents that suit the building. With planar back-lighting, for instance, modern buildings with glass facades continue to convey a sense of transparency and lightness after dark.

Spots delivering highly focused beams of light direct the eye to details such as cornices or historical ornaments, glancing planar light emphasizes the relief of natural stone facades or wood elements. Wall luminaires and recessed ground luminaires with asymmetric light distribution are suitable options for this. Installed close to the building, they set subtle light accents. This solution is energy-efficient and reduces light pollution that could disturb neighbours.

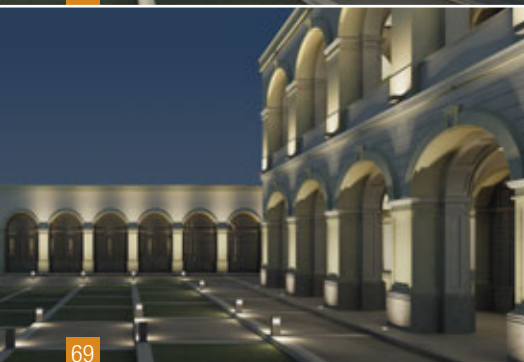
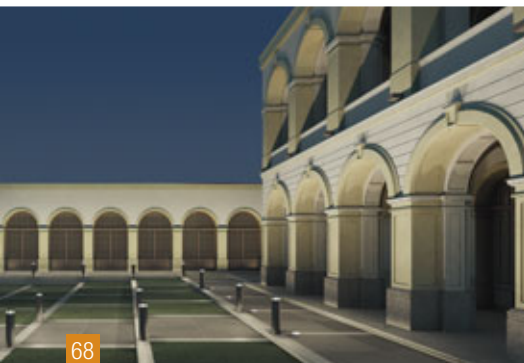
One of the major decisions taken when planning exterior lighting for a building is the choice of light colour. Neutral white light lends itself to clearly contoured modern architecture, warm light colours go well with historical buildings.

LEDs: energy-saving and low maintenance

Efficient LEDs are particularly recommended as a light source for outdoor applications. There are virtually no limits on the combinations of brightness and colour that can be realised. Light colours are thus not confined to homogeneous white; a total of 16.7 million colours are available. And in contrast to fluorescent lamps, LED modules present no problems for maintained operation at temperatures even as low as -20°C. Another advantage is longevity: thanks to the long life of LEDs, expensive maintenance work – especially in inaccessible places – is unnecessary.

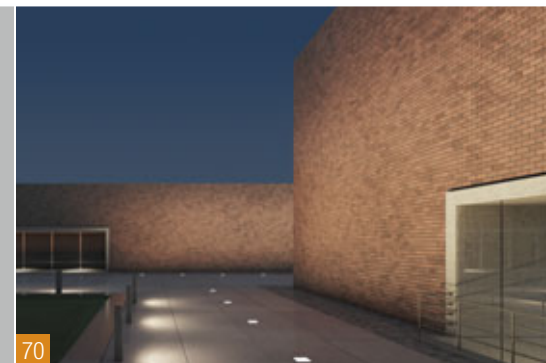
[65] The lighting concept emphasizes the finely structured historical facade of the building. LED facade luminaires use glancing light to set attractive accents. They are also energy-efficient and virtually maintenance-free.

[66 + 67] Media facades on which still or moving images can be presented are attention-grabbers. More than 22,000 dots of LED light are almost invisibly integrated into the facade. Each LED can be addressed individually by a lighting management system.



Eye-catching facades

The interplay of light and shadow at night gives a facade a new face. The effect of the light is determined by the luminaires and their emission characteristics. Planar illumination [68] can be realised with projector luminaires or floods installed at a distance from the building. Luminaires installed close to the building [69] emphasize details such as mouldings. Recessed ground luminaires with an asymmetric, wide-angle beam [70] highlight vertical wall surfaces; recessed spots delivering a focused beam of glancing light [71] lend depth to surface structures. A combination of floodlights and lights close to the building makes for dramatic facades at night. Light from inside the building can also be used to lend visual emphasis to the building. Supplementary light for orientation is provided by bollard luminaires or recessed ground luminaires flush-mounted in paths.





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Path and car-park lighting

Where the design of outdoor facilities is aesthetically pleasing, employees, customers and suppliers feel welcome. A thought-through lighting design emphasizes architecture, provides guidance and security.

Like facade lighting, a successful lighting design for outdoor facilities contributes significantly to the visual impression that an enterprise makes. It underpins the architectural language of the building and enhances the appeal of the entire complex. Outdoor areas are used not only by pedestrians and cyclists but also by motorists seeking or leaving a parking space. So one of the primary tasks faced by the lighting designer is to make paths and roads safe.

Differentiated exterior lighting facilitates orientation and reduces the risk of accidents. Lighting levels need to be higher at vehicle entrances and exits, steps, stairs and obstacles. These hazard areas require uniform glare-free lighting with comfortable illuminance on horizontal and vertical surfaces.

Step, stair and road lighting

Special attention needs to be paid to lighting for steps and stairs. The right light makes sure that tripping hazards are avoided and pedestrians can properly gauge the differences in elevation. A harmonious distribution of light with a balanced ratio of light and shade is important to ensure that steps stand out in relief and are clearly recognisable. Harsh and long shadows on treads should be avoided; they increase the risk of accident.

Bollard and wall luminaires with reflector systems that direct the light onto the ground are recommended for step, ramp and even path lighting tasks. They ensure that passers-by are not dazzled and that disturbing stray light is avoided. Excellent lighting for guidance is provided by linear arrangements of recessed ground luminaires: they help visitors find the way and at the same time set accents.

Access roads and parking bays can be marked for easy identification with column luminaires and light stele. Bollard luminaires or discreet recessed ground luminaires


separate the parking areas for motorists and cyclists and mark adjacent footpaths. This facilitates orientation for employees and visitors. A comfortable background brightness outdoors also keeps “unwelcome guests” at bay.

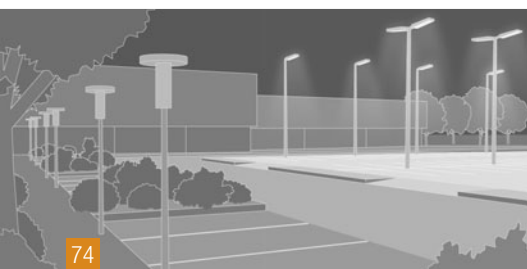
Luminaires and lamps

Luminaires that are used outdoors need to meet high requirements and should not have a degree of protection lower than IP 44. This guarantees that they are adequately protected against moisture, temperature fluctuations and foreign particles. High-pressure discharge lamps or LEDs make for efficient lighting.

Lighting management for greater convenience, comfort and efficiency

Interesting lighting effects and high comfort, convenience and efficiency can also be provided outdoors by lighting management systems. They control the brightness of the lighting and deactivate individual groups of luminaires at night or weekends when paths and parking areas are not used.

 More information on this subject is provided in the booklet *licht.wissen 03* “Roads, Paths and Squares”.



Parking facility lighting

Good lighting [74] reduces the risk of accidents in circulation areas. This is particularly important at vehicle entrances and exits. DIN EN 12464-2 sets out the maintained illuminance required: a minimum of 20 lux is required for heavy traffic, 10 lux for medium traffic and 5 lux for light traffic. For indoor parking facilities, DIN EN 12464-1 stipulates at least 75 lux illuminance for the general lighting. Vehicle entrances and exits need to be illuminated to at least 300 lux during the day; 75 lux suffices at night.

[72] Showing the way: column luminaires with a secondary reflector floodlighting system and LED recessed floor and wall luminaires provide guidance for employees and visitors in the evening and attractively illuminate the outdoor facilities.

[73] The vehicle entrances and exits of an indoor car-park need to be illuminated at night to at least 75 lux.

Safety lighting

Ensuring safety and preventing accidents are important lighting tasks. A safety lighting system ensures that people can get their bearings and reduces the risk of accidents in the event of a power failure.

Where people are present in large numbers, safety lighting is a must. It ensures that a company's employees and guests can evacuate rooms and buildings safely in the event of a mains power failure. Safety lighting needs to kick in automatically in an emergency and provide an adequate level of basic lighting from a mains-independent power supply, e.g. battery pack.

Escape sign luminaires mark the route out of a building; safety lighting facilitates orientation and prevents accidents.

Employers are legally obliged to protect their employees from potential sources of harm at the workplace. This includes

guarding against general accident risks, for if lights go out as a result of a power failure, any employee may be exposed to danger if he cannot find the exit in the dark or if he falls and sustains injury on the escape route as a result of being unable to see.

Safety and escape sign luminaires ensure that people can use the escape routes in the building and quickly access fire extinguishers and protective equipment. Adequately dimensioned, regularly maintained safety lighting installations help prevent panic and can save lives. Workplace regulation ASR A2.3 requires safety lighting for work premises with:

- a large number of occupants,

[75 + 77] Safety luminaires and escape signs indicate the way out of the building in an emergency.



- a large number of floors,
- particularly hazardous areas,
- complex escape routes,
- rooms that are used by persons not familiar with the premises,
- open-plan offices and large halls that need to be crossed,
- rooms that are not served by daylight.

Safety lighting provides protection

In all rooms with little or no incident daylight – such as stairwells, corridors or archive rooms – the illuminance of the safety lighting in the event of a power failure needs to be at least one lux. Information about the normative requirements set out for illuminance, lighting uniformity, glare limitation and power-on delays is provided in DIN EN 1838.

LEDs offer many advantages


Escape sign and safety luminaires are frequently in operation 24/7. So it is hardly surprising that they are now almost always

based on long-life LED technology. LEDs have an operating life of 50,000 hours or more. In practice, this means lower maintenance costs and an energy saving that, with optimised lighting technology, can be as much as 70 percent.

The compact dimensions of LEDs permit visually discreet escape sign luminaires of formally reduced design. Fitted with special optics to direct their light, LEDs can make particularly efficient escape signs. They need to be clearly visible even when the general lighting is switched on; the average luminance needs to be at least 200 cd/m², the luminance of the white areas of the escape sign 500 cd/m².

Low-load LED luminaires permit efficient eco-friendly installations; their compact dimensions allow discreet designs and separately installed safety luminaires. To achieve optimal efficiency with LED luminaires, supplementary optics and reflectors may be

required so that the number of luminaires installed can be reduced – while still ensuring that normative requirements are met.

 More information and planning advices contains booklet licht.wissen 10 “Emergency lighting, Safety lighting”.



Safety lighting

Safety lighting [76] is mandatory in large office and administrative buildings and generally ensures that employees and visitors can find their way through the building in an emergency and evacuate it swiftly, for example, in the case of fire and smoke. Safety lighting is automatically activated if the mains voltage fails and power for the general lighting is cut off as a result. Escape signs and safety luminaires show the way to exits and protective equipment and guarantee swift access to fire extinguishers. DIN EN 1838 requires at least one lux horizontal illuminance on the central axis of an escape route up to two metres wide.



Energy efficiency and refurbishment

The lighting installations in around two-thirds of German offices and administrative buildings are in need of refurbishment. Switching to modern lighting technologies sustainably improves the quality of the lighting in an office and at the same time saves energy and costs.

Low energy consumption is one of the quality features of a lighting installation today. Use of efficient lighting technology and intelligent utilisation of daylight is good for the environment, lowers operating costs and thus contributes to business success.

EnEV: Energy conservation is compulsory

European and national legislation increasingly obliges employers and service providers to use energy intelligently and, above all, sparingly. Energy “guzzlers” are being progressively banished from shop shelves. The best-known example is the incandescent lamp. Obsolete fluorescent lamps have also been banned from being placed on the EU market since 2010; high-pressure mercury vapour lamps will follow suit in 2015.

The energy balance of a building is dealt with in Germany by the Energy Saving Ordinance (EnEV), which requires that an energy performance certificate should be issued for every non-residential building with a net floor area over 1,000 square metres. The EnEV regulates buildings' maximum permissible total energy requirement. It not only covers heating, ventilation and air-conditioning but also takes account of lighting and hot water production.

Under the EnEV, architects, lighting designers and their clients need to establish the primary or actual energy requirement of all lighting installations prior to embarking on any new building or refurbishment project. The preliminary design needs to satisfy the requirements of the relevant EnEV and the DIN standards cited in it and receive approval before construction work commences.

Better quality of light, greater efficiency

An intelligently planned lighting concept achieves an optimal balance between quality of light and energy efficiency. The following components play a role in this:

- luminaires with high light output ratios and optimised optical control
- efficient light sources with high luminous efficacy ratings
- modern electronic operating devices and ballasts
- lighting concepts with different switching groups that can be individually and separately dimmed and controlled.
- lighting management systems that take account of incident daylight and the presence of persons in rooms.

Control systems offer a high degree of comfort and convenience coupled with maximum savings potential. Presence detectors, for example, ensure that luminaires are automatically dimmed or deactivated when no light is needed. If the sensors register persons present, the lighting is automatically re-activated. Even greater efficiency is achieved by harnessing natural daylight: compared to an old installation, the energy requirement can be lowered by as much as 75 percent. Investors and occupants also appreciate the flexibility that lighting management systems offer (for more information on lighting management, see pages 26-27).

Refurbishment makes sound economic sense

The savings potential is high: according to ZVEI estimates, more than 75 percent of office lighting in Germany is in need of refurbishment. As a general rule, old installations no longer meet current lighting quality requirements and consume too much energy. Over the years, the light output ratio of an installation and its components – i.e. luminaires, lamps and operating devices – is halved by soiling and material fatigue. That means poor quality of light and high electricity costs. The operating cost of a lighting installation today – the cost of energy plus maintenance – accounts for nearly 90 percent of the total cost. Against this backdrop, an investment in ergonomic, efficient

lighting is usually recouped within a few years.

As with a newbuild project, the refurbishment of a lighting installation should be carried out in consultation with experts right from the start – especially if the owner wishes only to replace individual components for reasons of economy. Caution is required here because a luminaire can lose its VDE certification if different operating devices or light sources are used. Where this is the case, the operator of the installation becomes responsible for its safety.

The replacement of reflectors is equally critical unless explicitly endorsed by the manufacturer of the existing installation. The use of different reflectors often changes the distribution of light. This can mean that the illuminance or glare limitation is no longer standard-compliant.

Support programmes

The German government and the European Union are both pushing for greater energy efficiency and sustainability and have created schemes that help small and medium-sized enterprises wishing to refurbish their lighting installations. Information about financial assistance for advice and investment is available, for example, from the state-owned KfW -Bankengruppe at www.kfw.de.

[78] Replacing old lighting systems with modern lighting technology makes sound economic sense. With a new installation, businesses and administrations can reduce the electricity they require for lighting by up to 75 percent.

Refurbishment checklist

Nine questions on the condition of your lighting installation	YES?
1. Have individual lamps failed?	
2. Are the luminaires soiled?	

→ In both cases, remedial action needs to be taken by cleaning the luminaires and replacing the spent lamps.

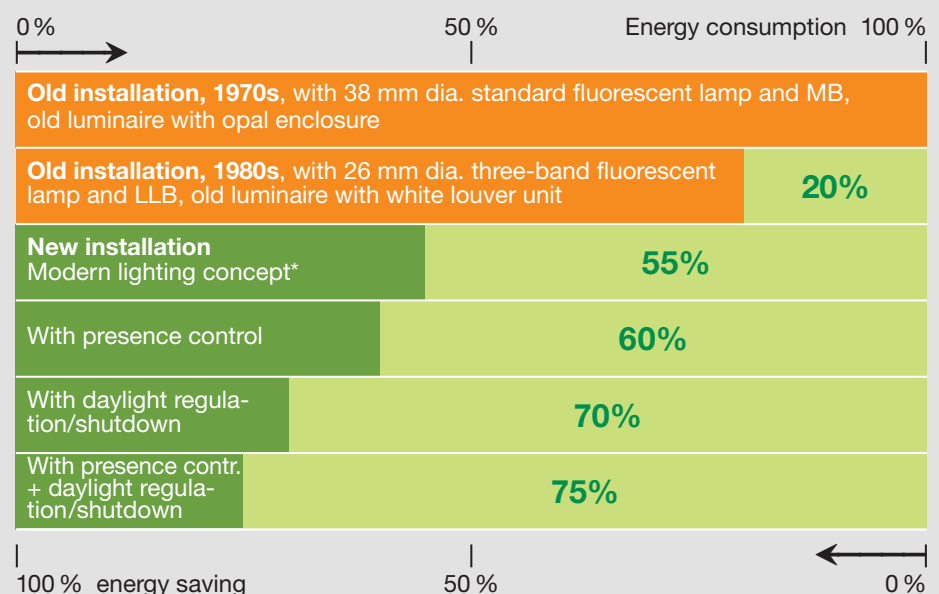
3. Is your lighting installation more than 15 years old?	
4. Do individual lamps blink when in operation?	
5. Is there too little light at your workplace?	
6. Do you feel dazzled when you are working?	
7. Do you see reflections or mirror images on your screen?	
8. Do lamps flicker when they are switched on or in operation?	
9. Is it impossible for you to deactivate or dim the lighting?	

If you answered YES to one of the questions from 3 to 9, you should have the lighting installation inspected

→ If the answer was YES to two or more questions, it is time to consider refurbishment.

→ Did you answer YES to four questions? You should contact an expert today and arrange for the preparation of a refurbishment concept.

Savings potential of interior lighting



* 16 mm dia. fluorescent lamp operated by EB with very low power loss, energy-efficient direct or direct/indirect luminaires with modern optical control technology

Green Building – lighting for sustainability

Modern buildings are supposed to be economical on resources, meet high technological standards and take account of human needs. In short, they should be sustainable. Quality is confirmed by certification – for which good lighting can help designers and clients pick up valuable points.

Sustainable building is in vogue: wood is used for facades, geothermal energy for heating – and the concept of “the green building” has been established to define it.

The ideal green building is one where sparing and efficient use is made of resources during both construction and subsequent occupancy. So the energy requirement of a building is an important criterion. Apart from environmental impact, the German Sustainable Building Council (DGNB) has identified a number of criteria for sustainability in architecture. Buildings have to take account of human needs, meet high technological standards and achieve a favourable cost-benefit ratio. Harmful impacts on environment and health are thus reduced to a minimum.

How does a building become a “green building”?

In recent years, a number of certificates have been developed to identify a sustainable building. The major seals of approval for office buildings are issued by the DGNB and the US Green Building Council.

The DGNB has assessed newbuild and refurbishment projects since January 2009 on the basis of around 60 criteria in six quality sections. Depending on the number of assessment points awarded, buildings are granted a gold, silver or bronze certificate. The quality seal of the US Green Building Council is known as LEED (Leadership in Energy and Environmental Design). Developed in 2000, it assesses sustainability by measuring performance in six key areas.

What good is certification?

Certificates and quality seals are intended to motivate designers and their clients to create sustainable buildings. But certification has more than just a notional value; it also brings considerable practical benefits. By meeting the criteria of the certifying or-

ganisations, building owners and designers ensure that their construction projects are realised to high quality standards. Costs, e.g. for energy and maintenance, are kept low; expensive construction corrections are unnecessary; occupant satisfaction rises; working and living conditions are improved. Certification also means that companies draw public attention to concepts such as sustainability and environmental awareness.

Lighting makes a major contribution

Light plays an important role in sustainable construction. It influences a building's energy balance and impacts on the satisfaction and sense of wellbeing of the people who work or live in it. A number of the construction and refurbishment projects certified by the DGNB have also received awards for outstandingly sustainable lighting solutions. One construction company in Bielefeld created an office building that, among other things, combined daylight with sensor-controlled light from free standing luminaires to guarantee constant brightness at workplaces. At the same time, however, employees can adjust the lighting to suit their own personal needs. The new building was granted a gold DGNB certificate.

[79] An agreeable work environment has been created in this refurbished bank headquarter building in Frankfurt. For the resource-efficient approach to all aspects of the project, the building was awarded a platinum LEED and a gold DGNB certificate. Energy-efficient light plays a major role as a design tool.

[80] A back-lit handrail accentuates the staircase.

[81] In the conference room, the stainless steel panel ceiling with integrated light lines provides lighting that is both functional and agreeable.



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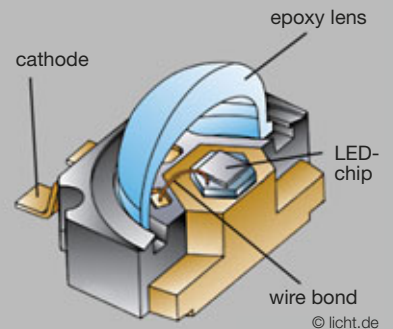


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How LEDs work

LEDs are based on compound semiconductors. Very little energy is needed to induce them to emit light. They produce a punctual light, the colour of which is defined by the semiconductor used.

LEDs are naturally coloured; white light is produced by applying a film of phosphor. To protect LEDs from environmental influences and simplify the electrical contacts, they are encased in a plastic housing. The light is directed by lenses.



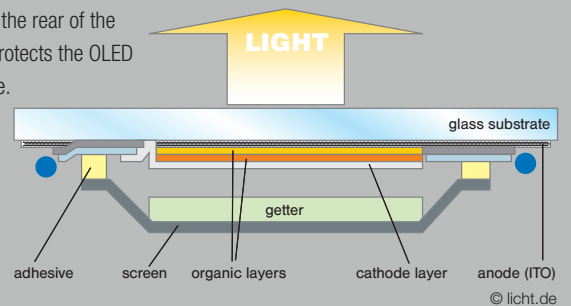
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How OLEDs work

OLEDs consist of extremely thin layers of organic material embedded between two planar electrodes. When a current is passed through them, they emit visible radiation – light. As with LEDs, the colour of that light is determined by the molecular structure of the semiconductor used. Because OLEDs respond sensitively to oxygen and moisture, they are encapsulated.

A "getter" on the rear of the component protects the OLED from moisture.



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Innovative LEDs and OLEDs

LEDs delivering a high quality of light are making major inroads in the world of general lighting. They are also saving resources in office lighting. No other lighting technology combines so much freedom for the lighting designer with high energy efficiency and low maintenance.

A source of white or coloured light for indoor or outdoor use – LEDs today offer innovative solutions for nearly every lighting application. They are aesthetically attractive and have an impressively long lifespan. LED luminaires operate for up to 50,000 hours or more – which works out at 11 hours a day, 250 working days a year for around 18 years. Fluorescent lamps, by comparison, need to be replaced after around 18,000 hours.

LEDs for a “green” future

LEDs can make a big difference in terms of lighting quality and resource efficiency – even in office lighting. The advantages they offer at a glance:

- high efficiency
- long life and thus lower maintenance costs
- white or coloured light
- variable colour temperature
- good to very good colour rendering
- infinitely dimmable and ideal dynamic lighting solutions
- robust in operation – impact-, vibration- and switch-resistant; no harm done by frequent switching and dimming
- reduced heat input and thus lower air-conditioning costs
- UV and infrared-free beam
- no mercury

For sheer freedom of design in shape and colour there has never been a light source like the LED. Its compact dimensions allow it to be integrated practically anywhere.

LEDs are easy to dim and control – and in conjunction with appropriate control systems enable light to be optimally tailored to human needs.

Quality pays off

LEDs really play out their many advantages when used in complete LED luminaires or LED modules. As replacement modules or as integral LED luminaires, they are already competing with energy-saving lamps in


the downlight segment of the market. And as planar luminaires, they are fine-tuning their luminous flux and colour-change capacities to office lighting requirements. It is also becoming increasingly easy to integrate new-generation modules in LED luminaires if a module needs to be replaced or efficiency has doubled.

The market for LED lighting is still growing apace. The product range is wide and deep – but not every product lives up to its promise. Inferior lighting quality and poor thermal management are often not identified until after installation. It is all the more important, therefore – especially with LED solutions – to ensure that the manufacturer guarantees uniform high quality. Thanks to high efficiency, longevity and low maintenance costs higher investment costs are recouped after only a short space of time.

On the way to market: OLEDs

OLEDs are opening up whole new dimensions in display technology and lighting. While LEDs are a point light source, organic luminous diodes are the first truly planar light source. OLEDs are extremely thin and can be integrated into assemblies like other building materials. They also permit extremely flexible colour control and produce an agreeably uniform, glare-free light.

The first OLED products are already on the market. But experts reckon it will be a few years yet before they can play out their advantages in daily life.

 Further information to the topic offers booklet licht.wissen 17 “LED: The Light of the future”.

[82] LEDs are conquering the world of general lighting with high efficiency, longevity and aesthetic flair. The eye-catcher at the reception is the back-lit counter emitting diffuse light. Above the work surface, an undulating LED luminaire ensures good visual conditions.

[83] As the first truly planar light source, OLEDs deliver a pleasant glare-free light. The first products are already on the market. The modular luminaire over the conference table features a combination of LEDs and OLEDs.

Luminaire applications

A wide range of luminaires is available for office buildings and their exterior facilities. Sustainable solutions consider lighting characteristics, efficiency and the scope for integrating luminaires in intelligent control systems.

Whether the project is for a new or refurbished office building, early lighting planning is advisable. What kind of light is needed for what purpose has to be established before decisions can be taken on luminaires and lamps.

The choice of suitable lamps for an office depends on factors such as

- the nature of the visual tasks addressed
- structural conditions
- safety-relevant requirements
- room use and operational procedures.

Luminaires must also meet high standards in terms of quality and design. In conjunction with lamps, they help define the efficiency of the entire lighting system, should be easy to install and should have low maintenance requirements.

Lighting characteristics

The term 'luminaire' always refers to the entire electric light fitting. It includes the light source, electronics and optics. The luminaire protects the light source, distributes and directs its light and prevents glare.

The quality of a luminaire is defined by three factors. The intensity distribution curve (IDC) shows in which directions and intensity a luminaire emits light. The light output ratio indicates how much of the light generated by the lamp(s) actually radiates from the luminaire. The third lighting quality feature of a luminaire is glare limitation.

The light of the lamps needs to be optimally shielded and glare must be sufficiently limited for visual comfort and visual performance to be guaranteed.



Surface-mounted ceiling luminaires fitted with optically active microstructures ensure homogeneous glare-free light distribution. They can thus even be mounted directly over work-places and are a suitable option for room-related lighting.



Desk luminaires can supplement task area lighting. They provide additional light for the work surface and facilitate difficult visual tasks. To ensure that the supplementary light can be individually adjusted, desk luminaires should be dimmable and mounted on a movable arm.



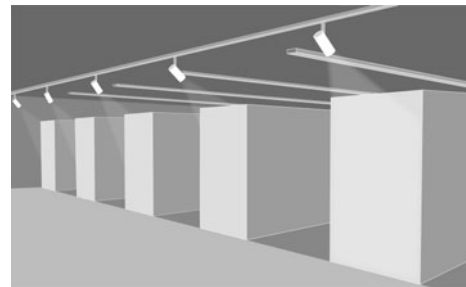
Recessed ceiling luminaires are flush-mounted in the ceiling. Only the light makes an impact, the luminaire housing is out of view. In offices, recessed ceiling luminaires are generally positioned parallel to the window wall. Correct louver technology ensures good anti-glare shielding.



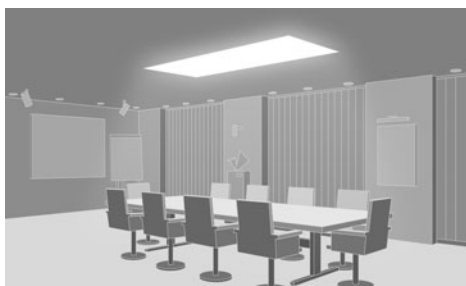
Pendant luminaires are suitable for planar office lighting and double as an element of interior design. They combine efficient direct light for the workplace with indirect light for agreeable ceiling illumination.



Downlights, with their simple design, take a back seat to architecture. Wide-beam models are used for general lighting in corridors and offices. **Free-standing luminaires** are a flexible option. Many provide both direct and indirect lighting and should be individually dimmable.



Power track systems are a flexible solution. Luminaires and spots can be mounted on the track at any point via adapters. These systems are available for surface, recessed or pendant mounting on ceilings or for wall mounting.



Luminous ceilings make a room seem bright without glare. Like **luminous walls** or **recessed planar luminaires**, they can be dynamically controlled and are a good choice for entrance areas, conference rooms and canteens.



Cornice luminaires are an architectural design tool and an eye-catcher in prestigious areas and aisle zones. They cast indirect light into the room from channels or plaster mouldings in or on walls and ceilings.



Light channel systems offer high flexibility. They enable linear luminaires, for example, to be combined for general lighting with high-performance spots for accent lighting. Light channel systems are particularly suitable for corridors, foyers and conference rooms.



Secondary reflector luminaires deliver high illuminance from above and play out their advantages mainly in rooms, foyers and stairwells with high ceilings. A high performance spot casts light onto a normally convex specular reflector, which scatters the light into the room.



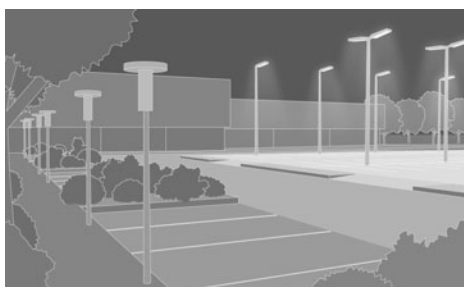
Recessed wall and floor luminaires subordinate themselves to the architecture. They are used in buildings for guidance or for casting walls and pillars in a dramatic light. In a stairwell, surface-mounted or recessed wall luminaires facilitate orientation and enhance safety. They cast extra light onto treads.



Wallwashers are available as recessed or surface-mounted luminaires. With their asymmetric light distribution, they ensure uniform illumination of vertical surfaces in corridors, foyers and offices. With appropriate operating devices, wallwashers can be controlled according to daylight and presence.



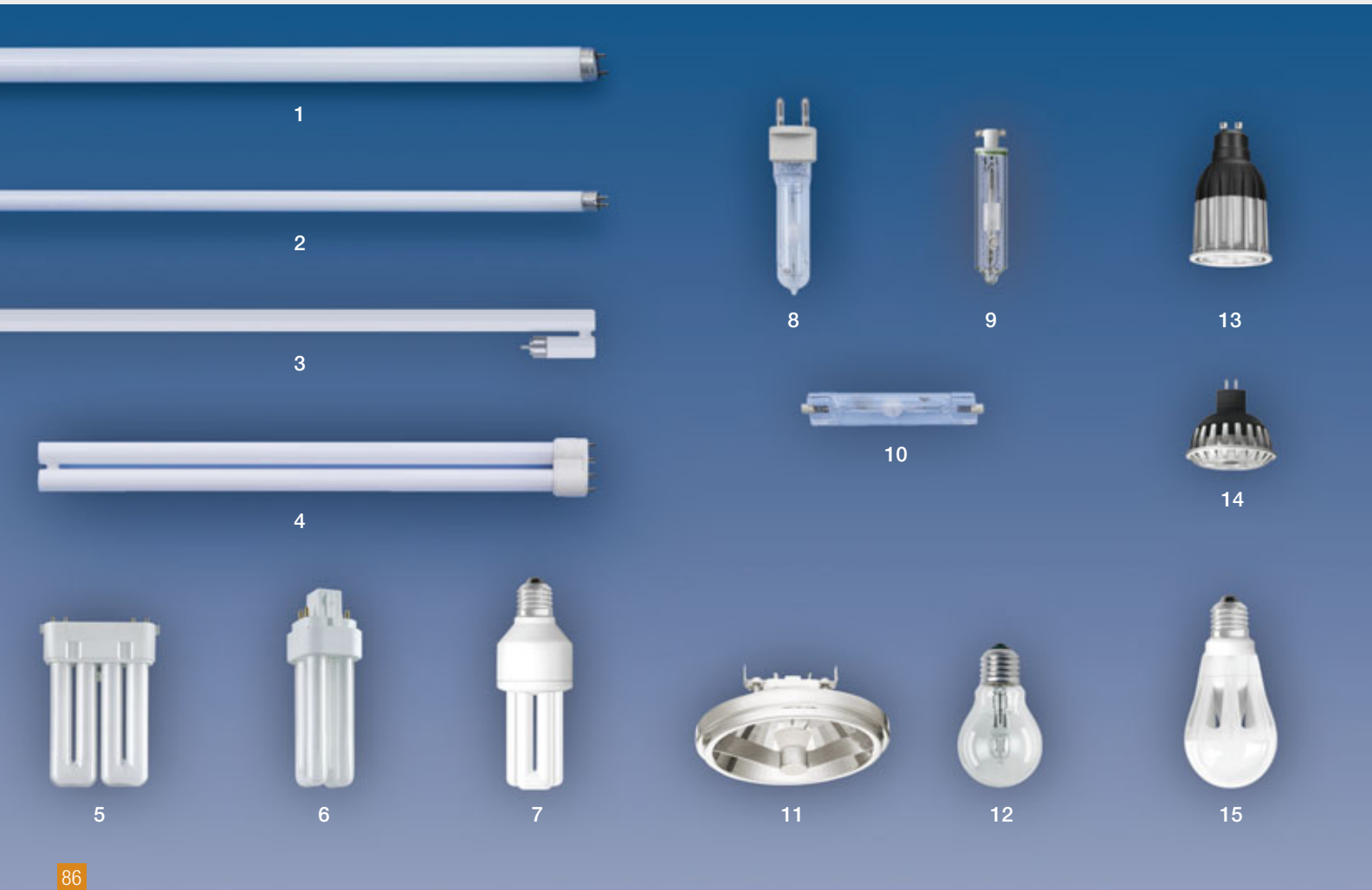
Safety luminaires facilitate orientation in the event of a power failure and ensure that buildings can be evacuated as swiftly and safely as possible in an emergency. They need to work independently of the mains, e.g. on batteries, accumulators or an emergency power system.



Column luminaires and light stele are used as technical and decorative outdoor luminaires. Luminaires mounted on tall columns are suitable for illuminating large car parks and vehicle access routes; light stele provide lighting for paths and smaller parking facilities. The lower the mounting height, the more luminaires need to be installed.

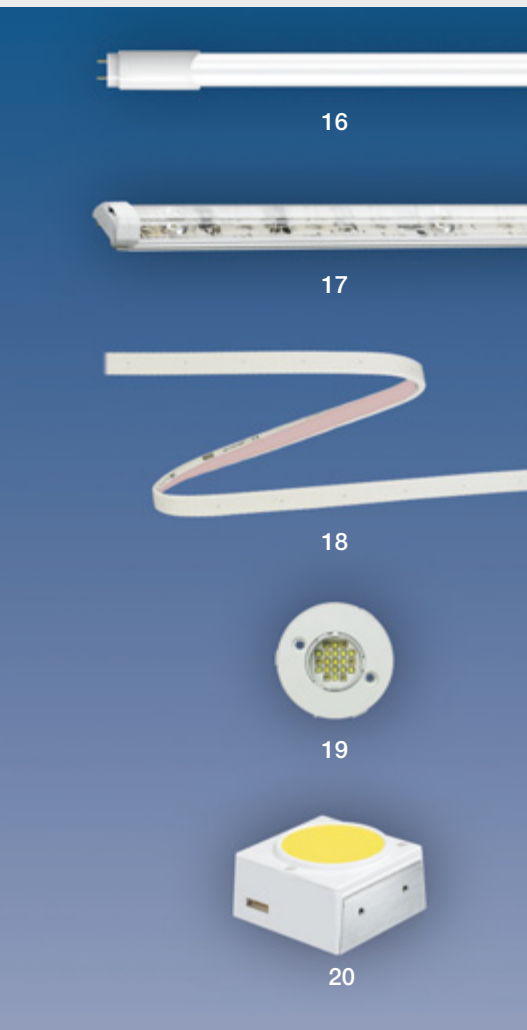


Wall luminaires, recessed ground and ceiling luminaires outdoors give office and administrative buildings a face at night. They accentuate facades or direct the eye to objects and plants. Outdoor lighting also provides orientation and illuminates paths, steps and stairs.



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No.	Lamp type	Power rating (watt)	Luminous flux (lumen)	Luminous efficacy (lumen/watt)	Light colour
Linear fluorescent lamps					
1	Fluorescent lamp, Ø 26 mm	18 – 70	870 – 6,200	61 – 89	ww, nw, dw
2	Fluorescent lamp, Ø 16 mm	14 – 80	1,100 – 6,150**	67 – 104	ww, nw, dw
3	Fluorescent lamp, Ø 16 mm	14 – 54	1,100 – 4,450**	67 – 104	ww, nw, dw
Compact fluorescent lamps					
4	2-tube lamp, elongated	16 – 80	950 – 6,500	67 – 100	ww, nw, dw
5	4-tube lamp, square	16 – 38	1,050 – 2,800	61 – 78	ww, nw, dw
6	1-, 2- or 3-tube lamp, compact	10 – 42	600 – 3,200	60 – 75	ww, nw, dw
7	3-tube lamp with integrated EB	8 – 30	380 – 1,940	48 – 65	ww
Metal halide lamps					
8	Single-ended with ceramic technology	20 – 400	1,600 – 41,000	80 – 108	ww, nw
9	Single-ended with ceramic technology	20 – 35	1,650 – 3,000	75 – 79	ww
10	Double-ended with ceramic technology	70 – 150	5,100 – 14,500	73 – 104	ww, nw
Halogen lamps					
11	Reflector design	10 – 100	350* – 33,000*	–	ww
12	Incandescent lamp design	18 – 105	170 – 2,000	9 – 18	ww
LED lamps					
13	Reflector design, line voltage	4.5 – 10	450* – 1,200*	–	ww, nw, dw
14	Reflector design, low-voltage	4.5 – 10	180 – 450	–	ww, nw, dw
15	Incandescent lamp design	2 – 12	95 – 900	45 – 75	ww, nw, dw
16	Tubular design, Ø 26 mm	11 – 30	630 – 2,600	58 – 85	ww, nw, dw
LED modules					
17	Rigid LED modul	11 – 30	100 – 2,100	–	ww, nw
18	Flexible LED module	24.5 – 72	765 – 3,650*	31 – 50	ww, nw, dw
19	Standardised LED module	9 – 39	800 – 3,000	52 – 85	ww, nw
20	Standardised LED module	17 – 44	1,100 – 3,000	55 – 75	ww, nw



Light sources

Choosing the right light sources is vital for good lighting. This page shows the main types of lamp for office lighting applications and their specifications.

Fluorescent lamps [1–3]

The distinctive features of fluorescent lamps are high luminous efficacy, good colour rendering and longevity. Operated by electronic ballasts (EBs) – a must in the case of 16 mm diameter T5 lamps – they deliver even greater energy efficiency and lighting quality. Use of a warm-start electronic ballast also extends the life of a fluorescent lamp. All fluorescent lamps can be dimmed with appropriate ballasts.

Compact fluorescent lamps [4–7]

Compact fluorescent lamps – also known as energy-saving lamps – have the same characteristics as fluorescent lamps but, thanks to their compact design, can be integrated in smaller luminaires. Models with built-in ballast are suitable for conventional screw lampholders [7]. Compact fluorescent lamps are also available with excellent starting characteristics, improved switching performance and in extra warm light colours (2,500 kelvin colour temperature).

Metal halide lamps [8–10]

The impressive features of metal halide lamps are their brilliant light and good colour rendering. Modern lamps with ceramic burner technology – operated by EB – are extremely energy-efficient, achieving a luminous efficacy up to 100 lm/W; their light colour remains constant throughout their life. They are a recommended option for foyers, corridors and rooms with high ceilings.

Low-voltage halogen lamps [11]

Low-voltage halogen lamps also deliver extremely brilliant light with very good colour

rendering characteristics. They can be dimmed with appropriate transformers. To operate low-voltage halogen lamps, a transformer is needed to reduce the voltage to 12 V.

230 V halogen lamps [12]

230 V halogen lamps can be operated directly on 230 V mains voltage. They produce a pleasantly refreshing brilliant light and are a popular choice for accent lighting, especially in reflector lamp designs. 230 V halogen lamps have a very good colour rendering index (Ra 100) and unlimited dimming capacity.

LED lamps [13–16]

As a result of the development of LED lamps – also referred to as LED retrofits – the advantages of LED technology can be used in many existing luminaires. With good colour rendering, a wide range of light colours and a lifespan of around 25,000 hours, they are an efficient, long-life replacement for conventional lamps. Where LED lamps are used to replace fluorescent lamps [16], light distribution is affected. Electrical reliability needs to be verified by a professional.

LED modules [17–20]

Outstanding efficiency and longevity make LED modules the solution of the future for technical and decorative office lighting. Modules generally consist of LEDs, wide angle lenses and reflectors. They have many applications, are practically maintenance-free, provide white and coloured light with good colour rendering and are infinitely dimmable and easy to control.

Colour rendering index R_a
(in some cases as range) Base

85 – 98	G13
85 – 93	G5
80 – 90	G5
80 – 93	2G11; 2G7
80 – 90	2G10; G8R; GR10q
80 – 90	G23; G24; 2G7; GX24
80 – 90	E14; E27; B22d
80 – 85	G8.5; G12; G22; GU6.5; GU8,5; GY22
85 – 90	PGJ5
75 – 95	RX7s; RX7s-24
100	GU4; GU5.3; G53
100	E14; E27; B22d
80 – 90	E14; E27; GU10
80 – 90	GU4; GU5.3; GU53
80 – 90	E14; E27
70 – 85	G13
75 – 80	–
80 – 89	–
80 – 95	–
80 – 90	–

* = in candela

** = at 25 °C ambient temperature

ww = warm white, colour temperatures up to 3,300 K

nw = neutral white, colour temperatures 3,300 K
to 5,300 K

dw = daylight white, colour temperatures over 5,300 K

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Office Lighting:
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