
WHITE PAPER

LIGHTING IN AND AROUND THE HOME

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1. INTRODUCTION

This white paper is the first of a series of thematic white papers dealing with various aspects of electrical installations in houses, flats and residential units. They are intended for architects, designers, specification writers, decision makers, installers and students.

In this white paper we focus on the electric lighting of houses and their immediate surroundings; however, this is not a course in lighting technology. There are already enough informative books and specific training courses on that subject. Instead we provide insight into various aspects of interior and exterior lighting and lighting controls that are important for the design of a lighting system. The ultimate aim is to design a lighting system which ensures that users or occupants feel comfortable during all activities and experience adequate lighting comfort. We gladly leave the detailed calculations to the experts at lighting dealers and wholesalers.

2. A BRIEF HISTORY

Thankfully, candles and oil lamps have long since been replaced by electric lighting, which is much safer and more effective. However, electric lighting was used very cautiously at first, with just one lamp per room for general lighting. Much later we allowed ourselves a bit of luxury with a chandelier in the living room. Even later came the fashion for flush-mount and surface-mount halogen spots, which had the disadvantage of sometimes creating large shadow areas. To make our living rooms cosier, we installed dimmers and upright lamps to provide indirect lighting.

As a result of campaigns to increase energy awareness, we have replaced our incandescent bulbs with energy-efficient bulbs where possible. Unfortunately, the first generation of energy-efficient bulbs could not match the warm glow of incandescent bulbs, and they are often difficult to dim. Traditional incandescent bulbs have now entirely disappeared from the market, partly due to EU regulations. Conventional incandescent bulbs convert a mere 5% of the consumed energy into light. The rest of the energy is lost in the form of heat.

Most residential lighting is currently provided by energy-efficient bulbs, which are more efficient than conventional halogen lights, and LED lighting has found its way into our homes.

3. DIFFERENT NEEDS

Our lifestyles have changed over the years. To offset our busy and demanding jobs, we need calm, security and relaxed surroundings. We try to find this in our homes by making them cosy and comfortable. Reading a book, watching television or a film, playing with the kids or reading to them, cooking and eating, entertaining guests, sharing an intimate evening with our partner, writing, studying, working on the computer, listening to music or playing music, barbecuing, gardening, washing, ironing, doing odd jobs – these are all activities we like to do in our homes and gardens. Suitable lighting for these activities is essential, because it prevents eye strain and stress from insufficient light, glare or deep shadows.

Despite our altered needs, in practice we often see that traditional ideas about lighting still prevail. Houses and flats are still being built with a single lighting point in the middle of the ceiling for each room. But it doesn't have to stay that way.

4. A FEW GUIDELINES AND TIPS

- To determine how much light is needed for a particular room or location, we always need to know what activity will be performed there. Hallways and passageways need less light than a room used for reading or a kitchen worktop. The following table shows some examples of recommended illuminance values.

Room	Activity	Illuminance (lux)
Bedrooms	General lighting	50 to 100
	Reading light	200
Children's room	General lighting	100
Bathroom	General lighting	100
	Dressing room	500
Living room	General lighting	100
	Reading or sewing	500
Kitchen	General lighting	300
	Worktop	500
Stairs and hallways	General lighting	100 to 200
Work room	General lighting	300

- In bedrooms, reading lighting is provided next to the bed in addition to general lighting. In children's rooms, adequate lighting must be provided at the desk. Indirect lighting can be used for general lighting if so desired as it has the advantage of low glare.
- In the bathroom it is a good idea to provide two non-glaring downlights at the washbasin, to the left and right of the mirror, in addition to general lighting. Halogen lighting mounted above the washbasin is undesirable as it casts deep shadows on users' faces.
- The large number of different activities carried out in the living room make it unacceptable to work with a single central lighting point. Lighting points at several locations, possibly divided into lighting groups, are recommended. As well as ceiling light fittings and wall light fittings, you can use moveable mood lights and upright lamps to increase the flexibility of the installation. In the dining room, which is often part of the living room, lighting above the table is recommended. The faces of people at the table should also be lit, but without irritating glare.
- The kitchen is a work area which needs sufficient lighting, both general and on the worktops, the cooker and the sink. If wall-mounted cabinets are fitted above the worktops, the lighting should be located under the cabinets instead of in the ceiling.
- Lighting in stairwells and hallways is essential for safety but must be non-glaring. Central lighting can be used to create a cosy atmosphere, but focused lighting should be used to illuminate photos, paintings or tapestries on the walls.
- Lighting in work areas (laundry area, garage, office, etc.) should allow the activities in those areas to be performed efficiently.
- Various types of light fittings (fixed and moveable, ceiling and wall lighting) should be provided in the same room, to enable flexibility in the lighting configuration. If the lighting is always the same, it eventually becomes dull.
- Different types of bulbs usually have different colour temperatures. This can also be used to create variety in the lighting mood.

5. LED LIGHTING

We all have LEDs in our homes in some form or another, such as smartphone torches, bicycle lights, and solar powered lights decorating the garden. However, chances are that in most places inside your home you are still using light bulbs, halogen light or energy saving lamps. It is important to understand that these lamps consume significantly more energy than LEDs. At the end of the 20th century, the use of LEDs in general lighting was still in its infancy. However, since the turn of the century, there has been a lighting revolution and LED lighting is on its way to becoming the norm, both inside and outside the home. Because LED lighting has become established in the lighting world, we take a brief look at what it is and how LEDs are currently used. We also discuss the specific advantages of LED lighting.

5.1. WHAT IS LED LIGHTING?

LED stands for **light emitting diode**, and that's exactly what it is. When power is sent through the diode's forward direction, it emits light. The technology and its characteristics have improved tremendously over recent decades. Hence, LEDs have grown to become the background lighting for nearly everything from analogue audiometers up to full-fledged lighting sources. The LED piece itself (the diode) is very small and is enveloped by a see-through holder with two connection cords. Technicians call this the LED light.

5.2. LED LIGHTS, LIGHT FITTINGS AND STRIPS

In plain English we also use the term LED light. However, in that case, it means something entirely different, more specifically the so-called retrofit lamps in one of the commonly used light sockets, and equipped with multiple LED lights. A control unit has been installed in the socket and such a lamp can then be used to replace light bulbs, halogen lights or energy saving lamps in existing fittings. The shape may seem similar to that of light bulbs and energy saving lamps but, in most cases, a metal cooling fan is found at the exterior.

In addition, we can opt for LED fittings, which are designed specifically for LED lights. For these the designers have taken into account the cooling aspect. The modern LED fixture no longer contains any loose LED lights as the LEDs and, in some cases, the control unit, have been fully integrated into the fitting. In general, an LED fitting contains multiple LEDs.

For the more creative individuals among us, there are also LED strips. These relatively flexible, pliable, rolled-up small strips are equipped with LEDs. You can cut off the desired length and connect a power cord. The LED strips can be used as indirect lighting in rooms or glass cupboards, and are particularly popular for improving the safety of staircase lighting.



Figure 1: A LED lighting fitting for exterior installation (Illustration source: Esylux)

5.3. HEAT MANAGEMENT

LEDs emit very little heat compared to previous light sources. Hence, they can be touched quite safely, unlike light bulbs and halogen lamps. On the other hand, they do not withstand heat that well and an overheated LED will have a shorter lifespan. This is why retrofit LED lamps are nearly always equipped with a metal cooling fan on the outside, which keeps the heat under control. Manufacturers do everything possible to keep the operating temperature as low as possible for LED fittings. However, LEDs are not affected by cold and can therefore be placed in an outdoor environment, even when the temperature is below freezing outside.

5.4. LONG LIFE

LEDs have an extremely long lifespan compared to other types of lamps. Let's compare the average lifespan of a halogen lamp of 3,000 hours with the lifespan of LEDs ranging from 50,000 up to 100,000 hours. When used 8 hours per day, the halogen lamp will last about a year, whereas LEDs will last for at least 17 years. However, this does not mean that they will always last this long in real life as LEDs are controlled by a feed and electronics. The latter needs to be of sufficient quality in order to match the LED's life expectancy.

This long lifetime has an additional advantage as the lamps or fittings do not need to be replaced so often. This is a real benefit for lighting in locations that are difficult to access, for instance high ceilings in entrance halls and staircases.

5.5. SUSTAINABLE DESIGN AND LOW HEAT

LEDs are not sensitive to vibration and cold. They can also be watertight, making them weatherproof and ideal for outdoor conditions.

In addition, they emit only a limited amount of heat, making it safe to touch them while they are lit. Small children cannot burn themselves, which is certainly not true of traditional light bulbs and halogen lamps. The limited heat emission is also an advantage for lighting in low-energy or passive homes. The heating system needs to answer the heating need, not the lights.

5.6. DIMMING AND COLOURS

In principle, LEDs are dimmable. However, not all fittings or LED lamps available in stores are able to be dimmed, depending on the type of controls that are built into the socket or fitting. The packaging for the LED lamp will usually mention whether or not the light can be dimmed.

Besides monochromatic and white LEDs, there also exist so-called multi-coloured LEDs, which contain three LEDs within a single casing. They are also referred to as RGB LEDs. RGB stands for the colours red, green and blue. With these three colours and the right controls, you can set a wide array of lighting colours, enabling you to choose the proper colour for each mood.

White LEDs are available in various colour temperatures, ranging from cold white to warm white light, comparable to the light emitted by a light bulb.

5.7. LOW ENERGY CONSUMPTION AND LOW ENVIRONMENTAL IMPACT

LEDs are extremely efficient as nearly all the supplied energy is transformed into light. Compared with other lamps, they produce far more light per unit of supplied energy (lumen/Watt), making them very energy-friendly compared to light bulbs and halogen lamps. This can lead to savings of up to 90% on the energy used for lighting, directly resulting in a lower CO₂ emission.

In addition, no sulphur, fluorescent powder, mercury fumes or other dangerous metals are used during production, as is the case with energy saving and halogen lamps.

5.8. UPWARD TREND

A few years ago, LED lighting was found in bars, hotels and office spaces. Since then, this type of lighting has increasingly found its way into our homes. Its purchase price might be slightly more expensive, but its long lifespan and much lower energy use result in a payback time of one to three years, depending on the average amount of operating hours per day.

6. EXTERIOR LIGHTING

Exterior lighting is particularly important for houses, for various reasons. First let's look at garden lighting.

6.1. GARDEN LIGHTING

A floodlit garden adjoining the living room and patio gives a feeling of more space, making the living room feel larger during the evening hours. An abundance of light fittings and bulb types are available for this, depending on the desired result. For light fittings the options are uplights and downlights. Uplights, for example, can be used to illuminate bushes or trees, whereas downlights are more suitable for lighting a footpath. You can also choose from ground spots, posts or wall light fittings. Pin light fittings are also available specifically for gardens and these are mounted on a pin pressed into the ground.

Amongst the options for garden lighting, there are even some small light fittings with their own solar panel. However, many of them only provide very limited light in terms of brightness and duration, which is a real problem in the winter. The batteries do not get fully charged during cloudy winter weather, so the light goes out quickly due to this lack of battery charge. Falling leaves and snow can also interfere with full charging. We therefore recommend additional wired garden light fittings but suitable cables or conduits must be provided for when designing the system.



*Figure 2: A downlight wall fitting, an LED floodlight, an LED ground spot and lighting posts side by side.
(Illustration source: PSM and Esylux)*

For the lights, a choice can be made between energy-efficient bulbs, halogen lights and LED bulbs. Energy-efficient bulbs need a 230 V supply whereas halogen lights and LED bulbs often operate from a transformer that provides a low voltage for the bulbs. However, the transformer also has to be connected to the 230 V mains. The installation must be safe in all weather conditions. This applies not only to the light fittings, which must be waterproof, but also to the cabling from the house to the light fittings. For instance, the cabling must be installed underground at a specific depth (depending on national and local regulations) to avoid damage from garden tools.

6.2. OTHER EXTERIOR LIGHTING

Lighting is often provided on the front wall, particularly at the front door. This allows visitors to be received with adequate light, and allows us to see who is at the door through a peep-hole in the door or on our video intercom. A driveway next to the house and the rear wall can also be lit to make it easier for the occupants to enter or leave the house from the side or the rear. This type of lighting increases user safety.

However, you must ensure that exterior lighting on the street side does not create glare for pedestrians, cyclists and vehicle drivers.

7. ORIENTATION LIGHTING

From time to time everyone does it, wandering around the house at night with the lights off. This is a dangerous habit. It can lead to falling down the stairs or colliding with an unexpected object. The reason why we behave this way is obvious. At night we prefer to have corridors, stairs and rooms dimly lit to avoid disturbing our drowsy condition. We do not want to become fully awake when we make a brief visit to the bathroom or go to the kitchen for a glass of milk.

Carefully positioned orientation lighting is a good solution in this situation, provided that care is taken to avoid glare. The best choice is a light fitting that provides indirect lighting or concealed LED strips. Orientation lighting only needs to provide enough light to avoid running into things, so flush-mount or surface-mount light fittings with LEDs are sufficient.

You should provide adequate orientation lighting. In practice this means every 1 to 2 metres. It can also be installed on stairs. Sometimes a night light can be helpful in the bedroom. Some children do not like to sleep in a completely dark room, and older people can easily find their slippers when they have to get up at night. In these cases it is advisable to install the night light under the bed as this prevents looking directly into the light from the bed.

Orientation lighting should go on automatically or stay on all night. Switch control is definitely unsuitable as the occupants would probably not use it. Instead, good options are a motion detector, a time switch with Astro function or a light sensor (see Section 9).



Figure 3: This indirect orientation lighting avoids glare. (Illustration source: Deltalight)

8. EMERGENCY LIGHTING

We are very familiar with emergency lighting in public buildings, hotels and stairwells in blocks of flats, but it can also be helpful in residential units. It can increase safety in the event of a power failure as it can be dangerous having the lights go out while bathing or cooking, especially for elderly occupants. Emergency lighting is discussed in more detail in the Assisted Living White Paper (number 8).

9. CONTROLS

9.1. SWITCHES

Switches are the most conventional control interface for lighting. At least one switch for general room lighting must be provided at each door that is an entrance or exit to the room. However, several switches can be placed at that position to allow the desired lighting scheme to be chosen when entering the room.

9.2. DIMMERS

Dimmers increase the flexibility of the lighting installation so that the light level can be adjusted whenever desired to create a comfortable lighting mood. Dimmers are also an excellent option for various places in the living room, seating area and dining room. Bedrooms and hallways are also suitable locations for installing one or more dimmers.

9.3. PUSH BUTTONS

Push buttons can only be operated at one point, which is usually at the bottom of the button. They look like switches, but they are either connected to a normal switch or a dimmer on the distribution board, or to the wiring of an Integrated Home System (IHS). The advantage of this installation technique is that the function of the push button can be changed by connecting it to a different remote switch or dimmer on the distribution board, or by reprogramming it in an IHS.

9.4. MOTION DETECTORS

Motion detectors can increase safety and convenience for occupants, particularly in hallways, stairwells, passageways, driveways and footpaths. Operating a switch is difficult with a lively toddler in one hand and a full shopping bag in the other. Walking along a dark hallway carries the risk of colliding with an open door or tripping over an object that shouldn't be there.

During installation the location of motion detectors need to be chosen carefully to ensure proper operation. The detection field is divided into several adjacent sectors. Motion must be detected in a number of adjacent sectors to trip the detector and cause the light to go on. More specifically, this means that motion detectors should face across the direction of travel instead of directly toward it.



Figure 4: Exterior motion detectors are a familiar sight. However, there are also interior versions that can increase safety and convenience for occupants. (Illustration source: Busch-Jaeger)

9.5. TIMERS

Timers can be used in situations where lighting is needed for a specific time. They are often used for stairs, hallways and other passageways as the light goes out automatically after the set time. In hazardous locations such as stairs, it is advisable to use fade-out timers. These do not switch off immediately when the set time expires, but instead gradually fade out over an interval of 1 minute or so. This gives anyone who is still on the stairs enough time to reach the bottom while the light is still on.

9.6. TIME SWITCHES

Time switches are used to automatically switch certain lighting circuits on and off at specific times. The start and stop times are configurable. For automatic control of garden lighting, it is best to use a time switch with the Astro function because the sun sets earlier and rises later in the winter than in the summer. Using fixed times therefore serves little purpose. The Astro function uses an internal calendar with sunrise and sunset times and is always configured for the region where it is installed.



Figure 5: Example of a time switch with Astro function. (Illustration source: Theben)

9.7. LIGHT SENSORS

Light sensors detect whether it is dark or light. They are often used outdoors, but there is also a use for them in certain places inside the home. For example, they can switch on orientation lighting when the light level drops too low in hallways and stairwells. For management of garden lighting, they are usually used in combination with conventional time switches. In that situation the light sensor switches on the lighting. The time switch outputs an Off signal a while later (at midnight, for example), and in the early morning (5 am, for example) it outputs an On signal, after which the light sensor switches off the lighting after sunrise.

9.8. IHS

If the home is equipped with an Integrated Home System (IHS), the entire lighting installation is controlled by that system. The push buttons, timers and time switches are usually integrated into the IHS. As well as individual controls, mood controls can also be implemented so that several lighting groups in a room can be simultaneously set to a particular mood by a single user action. Some examples include: a mood for watching television, a mood for playing with the kids, a mood for cleaning, a mood for entertaining guests, etc. All lighting can also be switched off by a general control button when leaving the home, or most of the lighting can be switched on in the event of trouble or a burglar alarm.

10. USEFUL LINKS

- Motion sensors inside the house:

<http://pitchbook.copperwire.org/motion-sensors-inside-the-house#>

- Automatic garden lighting:

<http://pitchbook.copperwire.org/automatic-garden-lighting#>

- Orientation lighting in your home:

<http://pitchbook.copperwire.org/orientation-lighting-in-your-home#>

- Have you selected your garden lights yet?:

<http://pitchbook.copperwire.org/have-you-selected-your-garden-lights-yet#>

- Ever found yourself sitting in the dark?:

<http://pitchbook.copperwire.org/ever-found-yourself-sitting-in-the-dark#>

- Do you already have LED lighting inside the house?:

<http://pitchbook.copperwire.org/do-you-already-have-led-lighting-inside-the-house-part-1#>