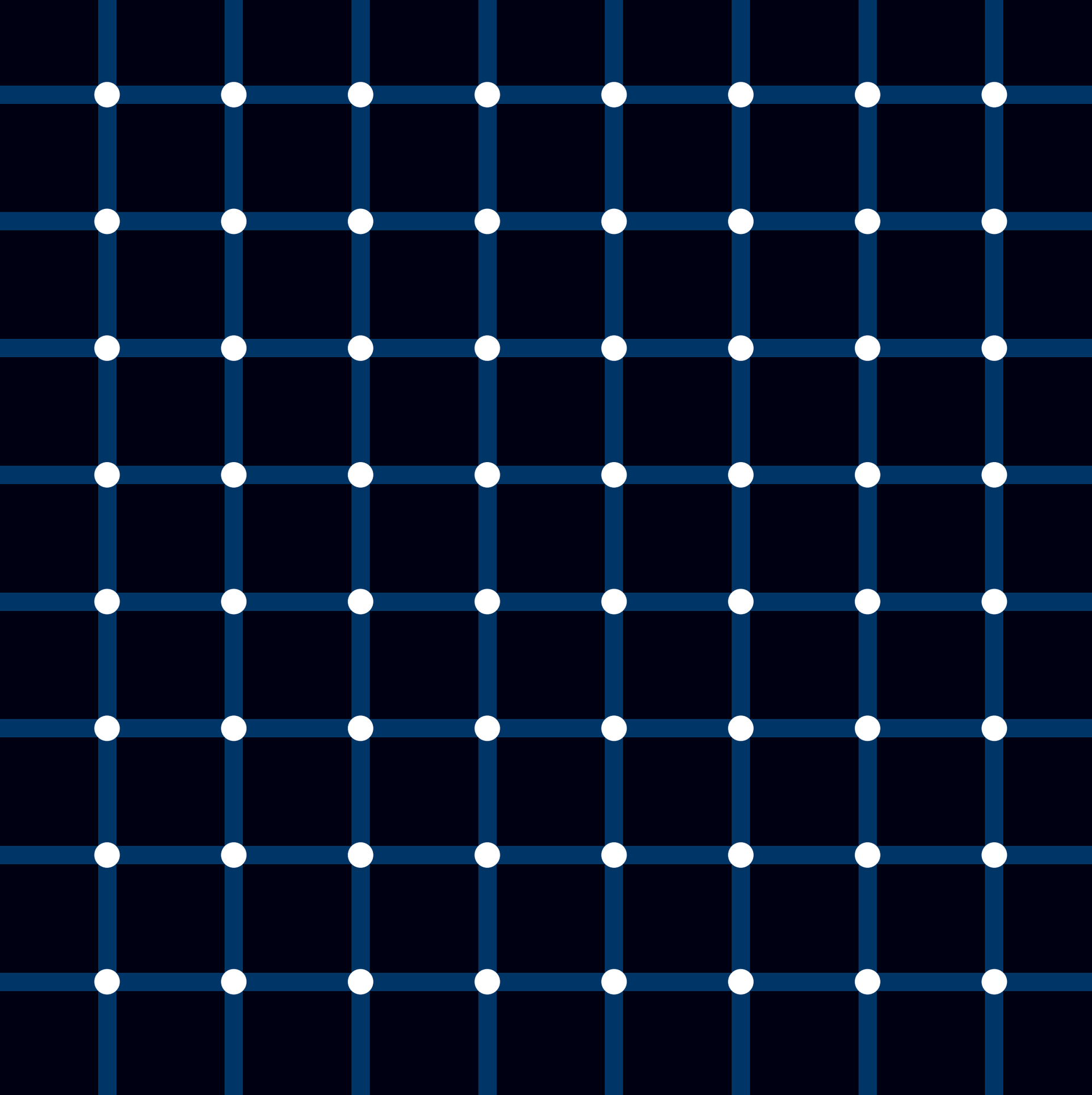


LIGHTING
QUALITY
STANDARD

LQS Philosophy

LQS Methodology

LQS Composer

LQS Philosophy

Welcome to new order

The living world is filled with striped and mottled patterns of contrasting colours, yet they are organized in harmony.

Welcome to new order

Why are zebras striped? Why do the geese fly in V-shaped formation? Why do all the living creatures need to eat, drink and sleep? Why is there a day-and-night cycle? How can an ant carry multiples of his own weight?

All of these questions share a hidden common point studied by scientists and philosophers for millennia. While there is a multitude of specific and complicated answers, the common one is simple: because the world has its rules and patterns. Because mathematical, physical or gravity laws influence each and every being on Earth.

Living by the rules is important. Abiding by laws, whether natural or societal, is similarly crucial. Otherwise chaos would ensue. The ancient struggle to find out whether the world is ruled by chance or specific rules and patterns, whether the fate is written in the palms of every human being still rages on. Do we influence the future ourselves? Is our fate decided by higher principles or is it a game of chance?

Existential set of rules can be applied to scientific research, industrial sectors or different types of business. Law and order is important both in life and in entrepreneurship. „In OMS we prefer order to chaos, "comments Martin Bílek, Head of Lighting Division in Research and Development Department of OMS, one of the most important global producers of luminaires and illumination solutions.

He is also a co-author and a force behind the unique system of rating lighting products and solutions. LQS stands for Lighting Quality Standard, a completely new set of rules for lighting industry technology. It is split into six parts and over 20 objective rating criteria by which any lighting device or solution in the world can be judged.

When Martin Bílek talks about conflict of order and chaos you can perceive his technical mind with systematic inner world and lofty preset goals. Barely over thirty years of age he already achieved a lot. He is one of the key employees of OMS, a force behind the creation of Research and Development Department. He represents both his company and his alma mater, Slovak University of Technology in Bratislava, in a number of scientific commissions both on national and international levels.

For him and OMS, the LQS is a step forward to a new level. „I waited for this a long time. Through LQS we can force the market to accept our vision of artificial light business, " Vladimír Levársky, the founder and CEO of OMS accentuates. He does not feel at all intimidated by the fact that the company from small country such as Slovakia has the ambition to dictate the rules of illumination rating to the global industry leaders. „We sprouted from nothing one and half decades earlier. Today we compete with the top global companies, " he explains.

The LQS methodology is separated into six elements with every one playing its irreplaceable part. Holistic attitude to science and life can be felt in OMS. Aristotelian rule that a whole can be more than a sum of its parts from his essential classic Metaphysics is literally true for LQS. A sextet of elements, logically split into Ergonomics, Emotion, Ecology, Efficiency, Esprit and Exceptionality are intertwined to create an indomitable and mighty whole of LQS.

The men behind LQS

Vladimír Levársky
Founder and CEO of OMS

Martin Bílek
Head of Lighting Division
in Research and Development
Department of OMS

"The whole is more than the sum of its parts."
Aristotle, Metaphysics.

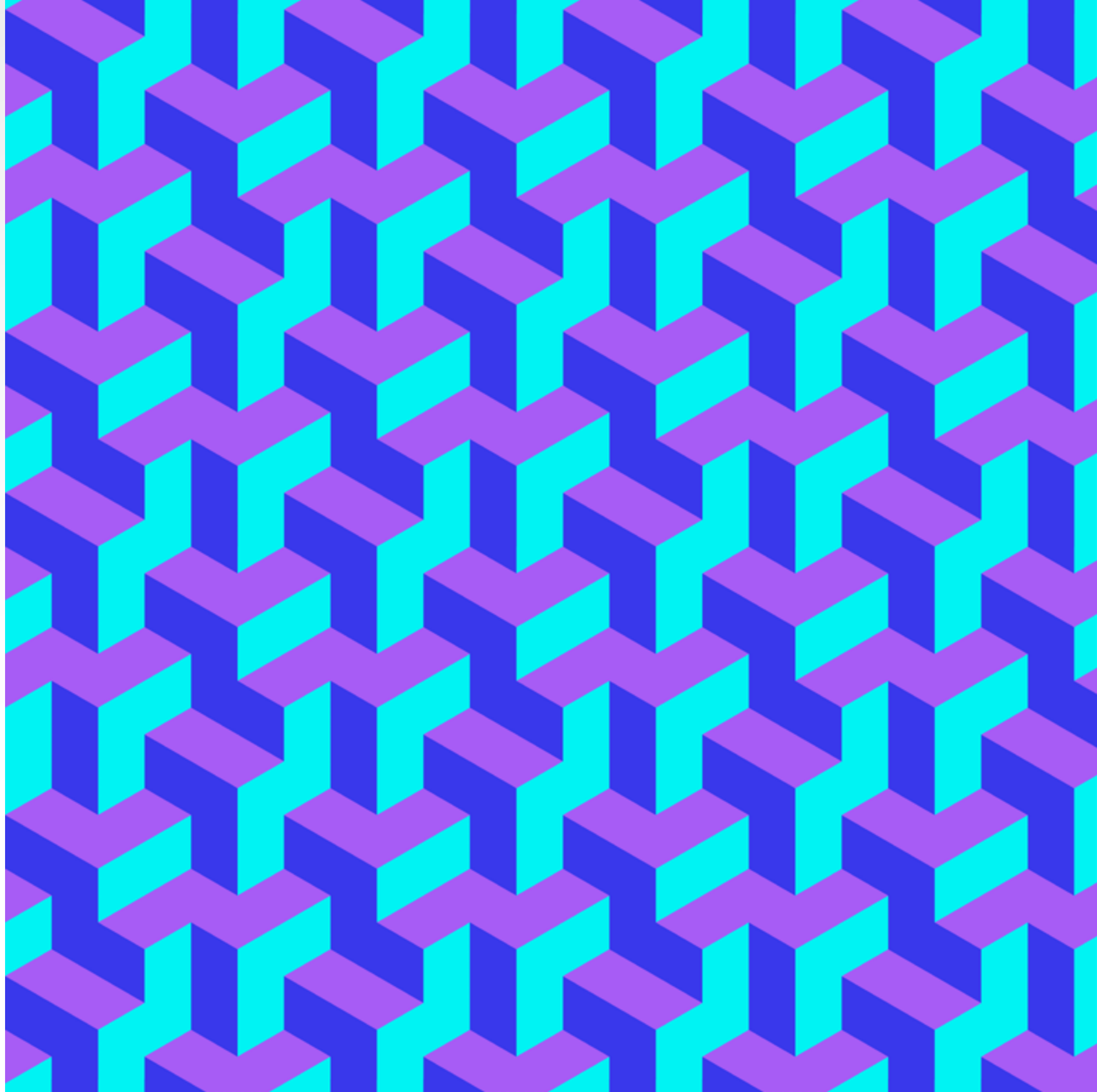
The first four contain the already mentioned objective rating criteria. The remaining two are subjective but have the same level of importance. „If you compare it to a building, the first four are the strong pillars. The remaining two are a superstructure, a roof that covers the whole system. One cannot function without the other, " says Martin Bílek, LQS co-author.

He accents that everything is connected. Parts of the whole cannot be rated separately, but rather inside a common framework. Otherwise everything would fall apart. Applying the long-term research of Nobel Prize laureate, Japanese physicist Makoto Kobayashi, to LQS is not a coincidence. Goal of Martin Bílek and his colleagues in OMS was not just creating a tool to rate luminaires. „We created a new order," the main protagonist and LQS co-author announces proudly.

From classical philosophy to quantum physics – does that seem extravagant? Or rather energetic and expansive? How about enlightening? Or a different term starting with E? In LQS there is just six E's but OMS attitude is characterized by many more positive adjectives starting with every letter of alphabet. LQS, however, is a complex philosophy, a true new order.

Visually the design is insipred by the unusual combination of op-art and permaculture. The combination of minimalistic design, optical illusion and natural patterns is again purely logical in the given context. The light is both natural and artificial, modern lighting systems are able to simulate daylight and day cycles. Ecological aspect is also very important in artificial lighting.

Discover the LQS concept on the pages of this book. Follow it and use it for your own gain when creating lighting solutions, in architecture and in sales. We are happy to share it. Welcome to new order. Welcome to LQS.



LQS Methodology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Ergonomics

Ergonomics

Colour rendering index

Glare prevention

Illumination level

- Task area
- Surrounding of task area

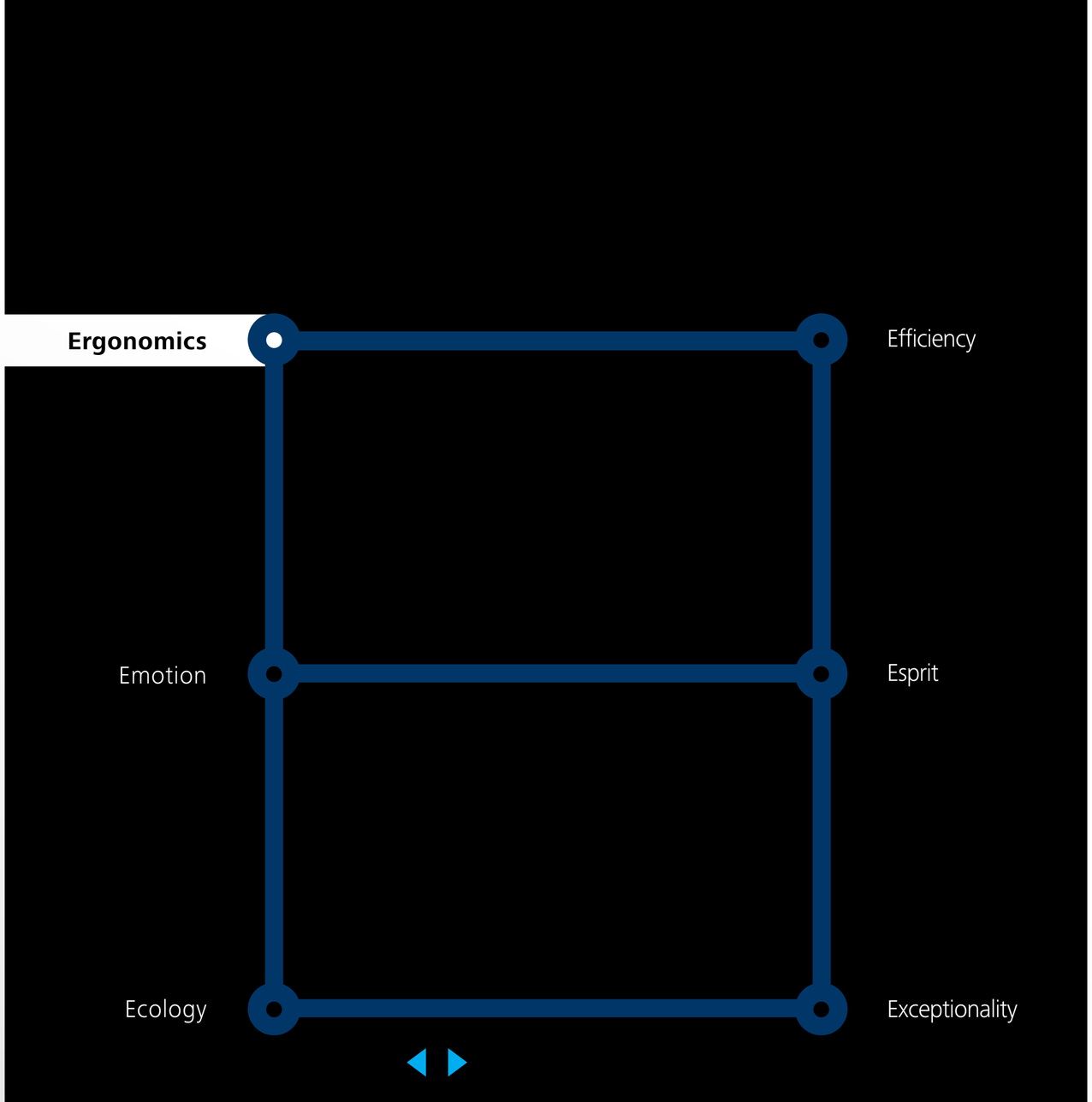
Lighting uniformity

Harmonious distribution of brightness

Examine the impact of light on the human eye.

The ability of a light source to reproduce the colours of various objects realistically in comparison with an ideal or natural light is the master rule in the world of illumination.

The key Is 6 E's



The ability of a light source to reproduce the colours of various objects realistically in comparison with an ideal or natural light is the master rule in the world of illumination. It helps the humans to make the choices correctly.

The goal of ergonomics is to examine the impact of light on the human eye and set up conditions that are comforting, add to human well-being and reduce stressful or dangerous situations that can be caused by adverse lighting conditions.

The ability of a light source to reproduce the colours of various objects realistically in comparison with an ideal or natural light is the master rule in the world of illumination. It helps the customers to choose clothing correctly, it allows the museum and gallery visitors to enjoy masterpieces as they were intended by their author. Simple adherence to several ergonomic standards can help prevent accidents, injuries, chronic eye and psychological conditions and other ailments.

With the people currently spending most of their daytime at work under artificial lighting, the correct design and set-up of the lighting systems is of utmost importance. Glare and high-contrast situations are to be avoided, while faithful colour rendering is cherished, especially in visually demanding tasks.

Colour rendering index (CRI)

Light and colour define the atmosphere of a room and influence our mood and sense of human well-being by their perceived “warmth” or “coldness”. Guaranteeing correct colour perception under artificial light forms is a very important part of the lighting designer’s task.

The appearance of coloured objects is affected by the interaction between the colours - i.e. the spectral reflectance of the objects we see and the spectral composition of the light illuminating them. In everyday life, we come across surface colours which can differ in appearance depending on how they are illuminated but which we recognize for what they are thanks to stored visual experience independent of lighting type.

For instance, we have a stored impression of the colour of human skin in daylight. Where artificial lighting lacks a particular spectral colour or exaggerates certain colours in its spectrum (as is the case with fluorescent lamps with CRI 80), skin seen under it may appear a different colour but will still look “natural” because of empirical compensation.

An extreme and most obvious example would be the ultra-violet lighting: it makes white extremely bright, the teeth glossy and the skin tone appears extremely tan. Of course, the extreme effect is obvious and the eye therefore knows that the colours are artificially shifted.

The effect a light source has on the appearance of coloured objects is described by its colour rendering properties. These are grouped into grades based on the “general colour rendering index” CRI. The colour rendering index indicates how closely the colour of an object matches its appearance under the relevant light source.

To determine the CRI values of light sources, fifteen defined test colours commonly found in the environment are each illuminated under the reference light source (CRI = 100) and then under the source being evaluated. The greater the difference in the appearance of the test colours rendered, the poorer the colour rendering properties of the light source under examination. In theory the CRI can go below zero, but such a result is discarded as the colour rendering of such source provides no useful data.

Under a light source with a CRI of a 100 all the colours have the same optimal appearance as under the reference light source. The lower the CRI index, the poorer the rendering of the surface colours of the illuminated objects.

In practical use CRI is an important aspect when choosing light sources. Those designated standard are cheap, but their CRI can reach only 60 or even less. The standards defined in EN 12 464-1 demand CRI of at least 80 for living spaces, inferior light sources are to be used only in corridors or storage spaces where colour rendering is of much less importance.

In several industrial sectors the demand for correct colour rendering is even higher, requiring light sources of CRI above 90. This is especially important in printing presses where correct colour assessment is vital, but can be as important in retail or in shop windows to correctly show the potential customers the colour of clothing, for example. For such shops the correct colour rendering is important also in the cabins where the customers try the clothes on. Wrong illumination there can lead to lower sales, with customers not being able to see the colour correctly. For LQS purposes, highest marks are awarded for CRI at or over 90.

LQS value

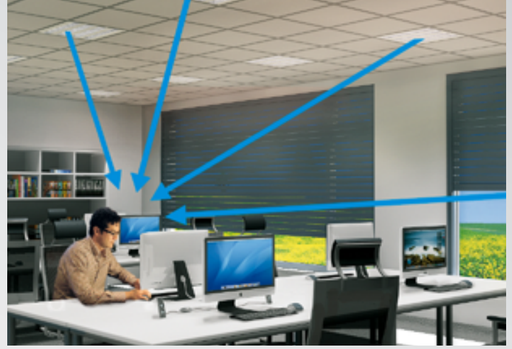
Colour rendering index (CRI)

CRI	LQS Value
>90	5
80-90	4
70-80	3
60-70	2
40-60	1
20-40	0

In everyday life, we come across surface colours which can differ in appearance depending on how they are illuminated but which we recognize for what they are thanks to stored visual experience independent of lighting type.

Glare prevention

When glare is present for a long time, eye strain occurs and can even lead to health problems.



Glare is a visual impression created by the presence of illuminated area in the field of view. Preventing glare is important from the work safety point of view: it can cause tiredness, errors and injuries. It makes a viewer feel uncomfortable, but does not necessarily cause eye strain. It makes reading a computer screen or paper documents more taxing and difficult.

Light sources with too high luminance can cause glare and complicate visibility of objects. To prevent this, the light source should be covered or partially obstructed and windows should be covered by protective shutters. The covering of the light source should provide that it is not directly visible in a 65-degree angle.

The human eye is highly adaptive and regenerative, provided the glare is only of a short duration and low intensity. When glare is present for a long time, eye strain occurs and can even lead to health problems. The rules of workplace safety aim to prevent such outcomes and great care is taken to diminish the potential glare to a minimum.

The prevention can be achieved by several means. First of them is correct placement of luminaires. The light from them should be directed to workspace in such a way that light reflected from visible objects would not be directed into the eyes of a worker when he is in the usual seating or working position.

The second recommendation is to use large luminaires with low luminance. Surface finishes that diffuse and scatter light should be used instead of glossy ones that create strong reflections. Last but not least, luminaires with appropriate distribution of luminous density should be used. A butterfly-shaped luminosity curve is desired with maximum luminosity in the angled parts of the curve.

Long-term eye discomfort due to insufficient or low-quality illumination may lead to eye strain. Its symptoms include irritated or itching eyes, headaches, diplopia (commonly referred to as double vision), spasms of facial muscles, conjunctivitis (otherwise known as pink eye), hot flushes, watering, increased nervousness and consecutively lower work performance.

If employees feel several of such symptoms the work safety rules demand a medical assessment of their condition. Repeated eye strain is a cause to re-evaluate the lighting system in the workplace. The overall tiredness is just a result of long-term eye strain, leading to loss of focus and attention. This can result in incorrect work practices and even injury. To prevent overall tiredness and consequent injuries, the standards in EN 12 464-1:2011 set up a framework for lighting depending on the demands of the job being carried out.

The probability of psychological glare can be estimated by the so-called UGR (Unified Glare Rating) method defined by International Commission on Illuminations (CIE, from the French term Commission Internationale de l'Éclairage).

UGR is defined as

$$UGR = 8 \cdot \log \left[\frac{0{,}25}{L_b} \sum \frac{I^2 \Omega}{p^2} \right]$$

where L stands for luminance of lighting parts of every luminaire in the direction of the eye (in candelas per square meter). Ω is a cut-off angle of a luminaire relative to the eye of an observer (in sr). p is a Guth factor of of spatial position of every single luminaire relative to the field of view. Finally, L_b expresses background illuminance (in candelas per square meter).

The maximum allowed UGR according to the EN 12 464-1 standard is 19 for most activities, with technical drawing demanding even more strict 16. Higher ratings are allowed for less critical environments such as reception (22) or archives (25). This method by its very definition takes into account all the luminaires in a given space.

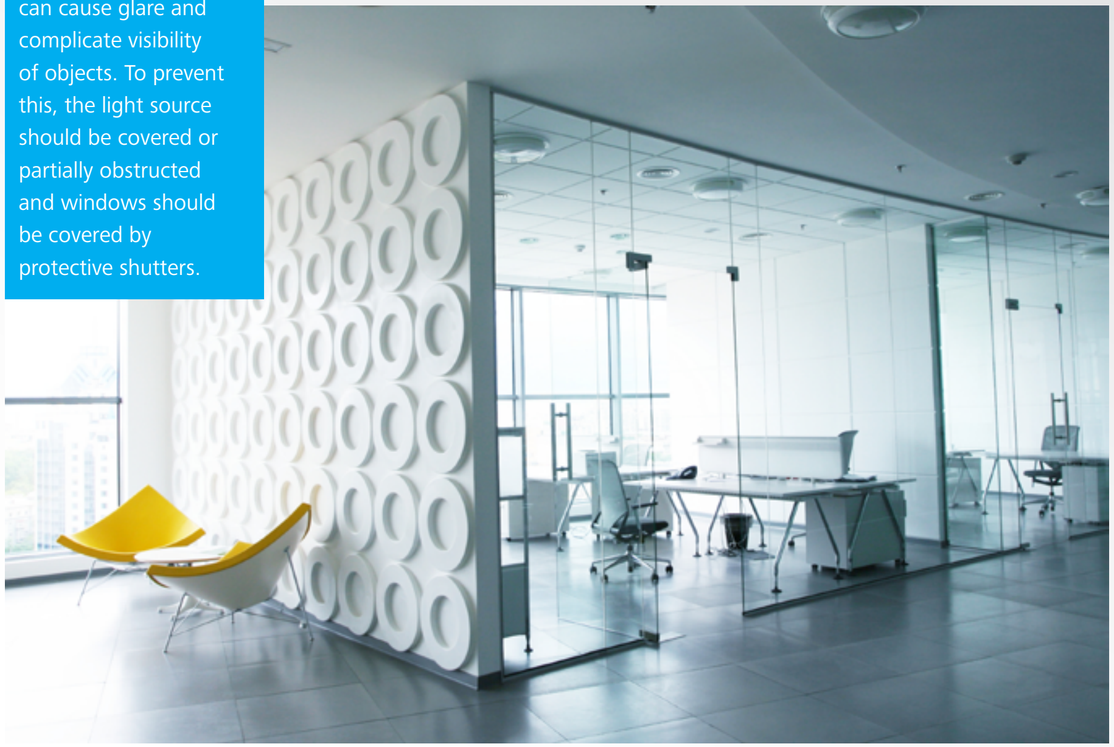
In special circumstances, such as when using screen with high-gloss finish additional care has to be taken to prevent direct or reflected glare. Work areas using such devices might need an individual approach: separate window shutters or even a specific setting of a lighting system. LQS awards a maximum of 5 points in the rating to the solutions which provide UGR below 16.

LQS value

Glare prevention

Glare prevention	LQS Value
UGR<16	5
UGR<19	4
UGR<22	3
UGR<25	2
UGR<28	1
UGR>28	0

Light sources with too high luminance can cause glare and complicate visibility of objects. To prevent this, the light source should be covered or partially obstructed and windows should be covered by protective shutters.



Illumination level

Task area

Surrounding of task area

Comfortable working or living environment can be beneficial for work productivity and the ability to relax and regenerate. The employee should feel well in his working environment. Illumination is an important factor to provide such comfort, improving the performance while reducing the risk of injuries from either bad visibility or stress caused by uneven illumination levels across workplace.

The illumination also affects the psychological well-being of a person depending on the luminance of the luminaire, chromaticity of lighting, uniformity of luminance and colours used in the environment itself. The correct lighting should be able to convey information necessary to carry out work tasks, to motivate, to set positive mood or creative atmosphere. The opposite then creates a probability of failure, injury, eye strain and tiredness.

Great care should be taken to avoid the possibility of eye strain, which leads to safety threats. This can be caused not only by improper illumination level, but for example also by flicker of fluorescent light, caused by faulty or cheap electronics that is driving these light sources. Low frequency flicker at 50 Hz is especially tiring and can lead to repeated errors and severe eye strain, which in the end may require medical attention. In such case replacement of the luminaires for higher quality ones is advised.

In extremely sensitive persons the frequent flicker can even lead to epileptic seizures. With increased tiredness the probability of epileptic seizures increases as well, making these faulty set-ups a health risk especially in larger areas with many workers. Such lighting failures can also produce unwanted effects in retail areas and in every other environment where a significant number of people are present.

For optimum performance the goal should be to mimic natural light as closely as possible or to even utilize it. This could be tricky given that prevention of glare is also required and glare-reducing glass finishes may negatively affect the quality of light.

Persons with disabilities may have different demands for illumination levels to carry out their tasks correctly, calling for dynamic lighting systems. These can adapt to the requirements of different types of workers. With digitally controlled lighting this task is even easier to achieve, further removing obstacles for employing disabled or elderly persons. For the visually impaired there can be stricter demands on illumination or contrast levels.

To keep illumination level constant and in line with the standards lighting sensors can be employed. These can keep the illumination levels constant even with deterioration of light source quality over time. Daylight sensors can then help mix artificial and natural light, keeping the illumination level constant as desired while helping to achieve significant energy savings during sunny days.

Persons with disabilities may have different demands for illumination levels to carry out their tasks correctly, calling for dynamic lighting systems.

Illumination level of task area

Illumination level of surrounding of task area

Task area

Task area is the most important space in terms of illumination quality. Here the work itself takes place and at the very least demands constant and sufficient lighting without any disturbing effects such as glare or flicker. The illumination of the task area should take into account the type of work being done, the focus it takes to carry out the task and also other demands. For example graphic-intensive work or any other visually engaging activity requires high-quality colour rendering.

For the designer this means having higher-quality light sources in mind, for the manager it means higher costs and extra care in maintenance. Replacing of the light source with an inferior type during maintenance could negatively affect the quality of the product or service, jeopardizing sales and increasing unnecessary costs.

The standard requires constant illumination level over a task area regardless of quality or age of the lighting system. Special care therefore has to be taken that even older light sources, which diminish their illuminance with age, provide the required illumination level. If necessary, for certain tasks additional luminaires may be needed in the task area.

Technical drawing for example demands not only high-quality illumination with very high CRI, but in many cases also shadow-free workplace. This can be achieved either with additional lighting that diminishes shadow formation or by setting up the task area so that it can be shadow free under the current illumination system.

From the LQS point of view, a lighting solution can either comply with the EN 12 464-1 standard or fail to do so, giving it a mark of either 5 or zero in the ranking.

LQS value

Illumination level (task area)

Illumination level (task area)	LQS Value
Yes	5
No	0

The illumination of the task area should take into account the type of work being done, the focus it takes to carry out the task and also other demands.

Surrounding of task area

While the correct illumination of the task area is of paramount importance, for the human well-being also its immediate surroundings have to be taken into account. Sudden illuminance drops immediately outside the task area may cause problems to see objects outside the immediate surroundings and cause unnecessary strain and stress. The standards therefore call for the proper lighting of surrounding of the task area.

The EN 12 464-1 defines the surrounding as the band at least half a meter wide around the whole task area. In this band the illuminance has to be at least 66 to 75 percent of the task area illuminance. Higher ratios are meant for lower illuminance areas. If a task area has a minimum illuminance set at 200 lux, the surrounding area has to have at least 150 lux. With higher values the ratio decreases. For the most visually taxing tasks the standard calls for 750 lux while surrounding must have two thirds of that value, only 500 lux.

Again, proper illumination level can be achieved and kept by using sensors and control of luminaires. An intelligent control system can dynamically adjust the illumination level even if task areas are not in constant position and dim or fade up the lights accordingly. And again, lighting systems should be used with overhead in mind as the quality of light sources and their illuminance deteriorates with age.

In the working environments without background natural illumination artificial background lighting has to be provided to keep comfort levels high. Dark walls create negative psychological reactions and background ambient lighting, defined in EN 12464-1, should be used to rectify the situation. The LQS standard once again awards 5 points for compliance with the standard or zero for failure to comply.

LQS value

Illumination level (surrounding of task area)

Illumination level (surrounding of task area)	LQS Value
Yes	5
No	0

Sudden illuminance drops immediately outside the task area may cause problems to see objects outside the immediate surroundings and cause unnecessary strain and stress. The standards therefore call for the proper lighting of surrounding of the task area.

Lighting uniformity

Lighting uniformity affects our perception of environment and our ability to navigate it. Uniform lighting allows us to perceive the environment continuously and without sudden breaks caused by lighting level drops.

The uniformity on room surfaces can be expressed as a ratio of the minimum illuminance and the average illuminance in a given room or space. The closer to one it is, the more uniformly lit the space is. The uniformity calls for a luminaire with very wide curve of lighting verging on the diffused and constant light scattering in all directions. With such a high uniformity comes also a perception of boredom to the space, as the lighting itself lacks any contrast and dynamism.

The uniformity also depends on the types of luminaires used, their spatial position and their number. Again the EN 12464-1 standard requires certain tasks to be provided with a certain uniformity of lighting. Just like in the case of glare and task area illumination, technical drawing is the most demanding, requiring a uniformity index of at least 0.7. Other focus-intensive tasks demand a ratio of 0.6.

Lighting and illuminance uniformity is an important factor in outdoor applications as well. On roads the illumination must avoid low uniformity ratios: the frequent changes of contrasting high- and low-lit road segments cause enormous eye discomfort, leading to stress and tiredness and therefore jeopardizing road safety. Human eye takes its time to adapt to new lighting conditions and frequent changes can for example cause some objects to be invisible. In the case of people such ignorance can have tragic consequences.

Lighting uniformity can again be achieved using sensors and other control mechanisms. A quality dynamic lighting system will be able to provide desired uniformity under changing circumstances, e.g. during daytime when sunshine can be the primary light source. The role of the artificial light is then keeping the uniformity as constant as desired by lighting those spaces that are further away from the windows and other sources of sunshine, such as skylights.

Uniformly lit environment also provides eye comfort for those working with PC screens, which are by themselves light sources. The lighting should take this fact into account and provide such level of illumination that does not create abrupt changes in illuminance between screen and the rest of the room. The uniformity according to the standards does not distinguish between task area, its surroundings and the background. To fulfil the criteria of the standard all parts of the room have to be taken into account.

As with previous criteria, for LQS purposes a solution receives perfect 5 points if it complies with the criteria of the standard, otherwise it gets a zero.

The uniformity on room surfaces can be expressed as a ratio of the minimum illuminance and the average illuminance in a given room or space. The closer to one it is, the more uniformly lit the space is.

LQS value

Lighting uniformity

Lighting uniformity	LQS Value
Yes	5
No	0

Harmonious distribution of brightness

Human vision is the most important sense for gathering information; the brain gets 80 percent of all information from visual cues. The quality illumination is the key to process and gather the information correctly. Brightness is the only factor to which our eye reacts. Correct illumination should therefore take distribution of brightness into account. The eye has different sensitivity of vision depending on the angle.

The most sensitive part is at 10 to 20 degrees from horizontal axis. In this section high brightness is to be avoided, as it could cause glare, which has negative consequences on well-being, comfort levels and health. In the case of glare the pupil is contracting, decreasing the perception and the ability to discern brightness levels. Quality of luminaires can help with the brightness distribution, but the interior design plays its part as well: proper furnishing of the space and the materials used affect harmonious distribution of brightness.

Brightness is a complex factor that can be defined as an illuminance of a surface as perceived by a human eye. In such a definition brightness can be expressed as a ratio of luminous intensity of a surface under certain angle to the surface area of its projection. Brightness is a directional unit, depends on luminous intensity in different directions and directional reflectiveness of a surface and the projected area of a surface in a given direction. Its unit is candela per square meter.

Brightness per unit area
Technical symbol: L
Unit: cd/m2
The standard light-related value for the impression of lightness is the brightness per unit of area, because only the eye perceives it. It is derived from the directed stream of light in relation to the perpendicularly illuminated area of the recorded solid angle.

Harmonious distribution of brightness is important for sharpness of vision and sensitivity to contrast, contrast being relatively small differences in brightness. Eye strain can be caused by too high a brightness, which can cause glare and too large contrasts in brightness, where eyes need to constantly adapt to significantly different lighting conditions. Setting the brightness too low can again cause strain, decrease the visual stimulation and therefore also work performance.

To achieve uniform brightness distribution all surfaces have to be taken into account and their brightness calculated. Once again, achieving optimum brightness conditions is a task for interior designer as well, as he needs to choose brighter colours for interior surfaces, walls and ceilings. Darker surfaces would work against the harmonious distribution of brightness and can cause feelings of oppression and anxiety.

The standard EN 12464-1 actually calls for specific reflectance of surfaces: for ceilings it is 0.7 to 0.9, the walls 0.5 to 0.8. The floor is the least important factor from the brightness and reflectance point of view, with required reflectance only 0.2 to 0.4. On the other hand, even furnishings and machinery are limited in their reflectance to 0.2 to 0.7. Which means they should not be much brighter than the walls, but also not too dark, as this works against the proper brightness distribution.

The main surfaces should be illuminated uniformly as well. The minimum illuminance of walls is set at 50 lux with uniformity over 0.1; the ceilings have their minimum at 30 lux with the same uniformity. Unlike the other factors, LQS awards 0 to 5 points based on illuminance level and its uniformity on room surfaces: the highest marks demand illuminance of walls of over 150 lux with uniformity of over 0.3. Same contrast is required for ceiling with illuminance over 75 lux. This is stricter than the EN 12464-1 standard requirements.

LQS value

Harmonious distribution of brightness

Harmonious distribution of brightness (contrast)	LQS Value
Em(wall)>150lx with Uo>0,3; Em(ceiling)>75lx with Uo>0,3	5
Em(wall)>75lx with Uo>0,3; Em(ceiling)>50lx with Uo>0,3	4
Em(wall)>75lx with Uo>0,1; Em(ceiling)>50lx with Uo>0,1	3
Em(wall)>50lx with Uo>0,1; Em(ceiling)>30lx with Uo>0,1	2
Em(wall)>30lx with Uo>0,1; Em(ceiling)>10lx with Uo>0,1	1
Em(wall)<30lx with Uo>0,1; Em(ceiling)<10lx with Uo>0,1	0

Ray, luminaire designed by Ján Štofko of OMS

Harmonious distribution of brightness is important for sharpness of vision and sensitivity to contrast, contrast being relatively small differences in brightness. Eye strain can be caused by too high a brightness, which can cause glare and too large contrasts in brightness, where eyes need to constantly adapt to significantly different lighting conditions.

Emotion

Emotion

Biological factor of illumination

- Availability of daylight
- Bluelight content
- Daylight simulation
- Dynamic lighting
- Tunable white

The illumination of room surfaces

- Vertical illumination
- Ceiling illumination

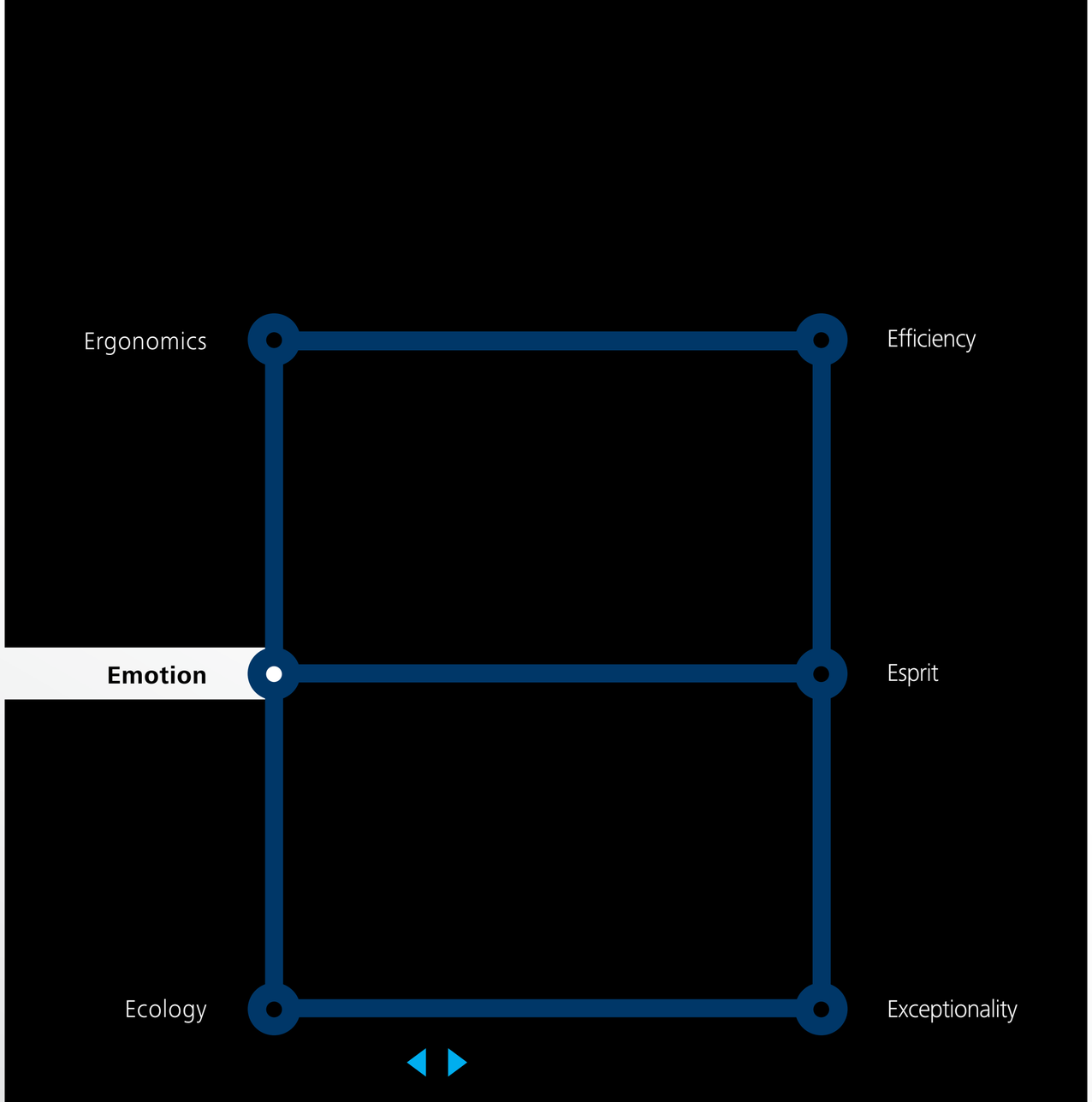
Emotional lighting

- RGB colour mixing
- Accent lighting
- Ambient lighting

Uncover the influence of light to human emotions.

Strong scientific evidence proves the effect on mood and perception through features such as colour mixing, biologically effective lighting or illumination of room surfaces.

The key Is 6 E's



LQS takes a holistic approach to the illumination of spaces, providing natural light to a variety of spaces, coming from natural angles in natural colours, mimicking the way the light has been perceived for thousands of years.

It is well known fact based on scientific research that light has a huge effect on mood and perception through features such as colour mixing, room area illumination or accent and ambient lighting. LQS takes a holistic approach to the illumination of spaces, providing natural light to a variety of spaces, coming from natural angles in natural colours, mimicking the way the light has been perceived for thousands of years, as the evolution programmed human circadian rhythms around such light.

If necessary, the new technologies allow for precise control of colour and focus, achieving a variety of effects in retail, leisure or industrial spaces. The scientific discoveries of the past decade have profoundly redefined the role of illumination in the environment and its effect on human well-being. The emotion aspect of LQS, unlike industrial standards, is set to reflect the new findings.

Biological factors of illumination

Availability of daylight

Bluelight content

Daylight simulation

Dynamic lighting

Tunable white

Availability of daylight

The human kind is spending much of the day in the interior spaces, as the modern style of living and working demands. The quality lighting of these spaces is therefore of paramount importance. Using the available daylight to the fullest extent is the very important. If there is a lot of sunlight available, the illumination should amend it, otherwise its role is to functionally supplant it. „Lighting has much higher importance for humans than just enabling seeing," says Marc Rea from Light Research Centre in Troy in USA.

There is a wealth of scientific evidence that illumination affects mood of the individuals, their performance, well-being and even physical health. Prolonged exposure to badly illuminated spaces can be hazardous to one's health. "When we do lighting audits in older factories, just walking through the corridors I can immediately see that the change in lighting would do wonders to performance and mood of the workers," Martin Bílek, Head of Lighting Division in Research & Development of OMS draws the picture.

The most important part is the correct illumination itself, the type of luminaire is secondary as long as it provides the desired effect. Human eye reacts amiably to large continuous areas of light hitting the eye. The most important are white coloured areas. The areas do not have to be directly illuminated – diffused light reflected from white walls helps human well-being as well. The lighting solution should utilize the reflections from walls and especially from the ceiling – the artificial sky – to the highest possible extent to provide lighting that feels natural and does not interfere with natural biorhythms.

The scientific research proposes to develop dynamic lighting solutions, ones that are in sync with natural daylight cycles. The artificial lighting is according to the different researches able to mess with melatonin production, a compound responsible for correct following of circadian rhythms. This research has been further supported by the discovery of a third photoreceptor in the eye sensitive to the blue part of the spectrum.

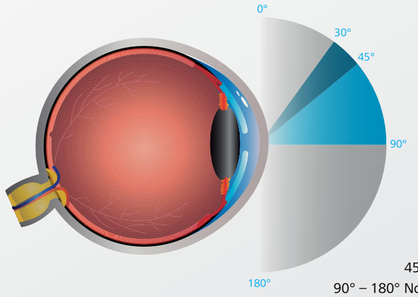
George Brainard and his team from Thomas Jefferson University found evidence of a novel circadian receptor in human eye in 2001 (Action Spectrum for Melatonin Regulation in Humans: Evidence for a Novel Circardian Photoreceptor, The Journal of Neuroscience, August 15, 2001) and their postulation has been one year later confirmed by David Berson who recognized the receptor itself (Phototransduction by Retinal Ganglion Cells That Set The Circadian Clock, Science vol. 295, 2002).

These findings changed the way we view light and its role. Moreover, the receptors are specifically adjusted to the light coming from above, as they are found in the lower part of the retina. The overall goal resulting from these researches is to turn the so-called holistic lighting into an industrial standard. Illumination should not only provide adequate lighting, it should be biologically effective.

Human eye reacts amiably to large continuous areas of light hitting the eye. The most important are white coloured areas. The lighting solution should utilize the reflections from walls and especially from the ceiling – the artificial sky – to the highest possible extent to provide lighting that feels natural and does not interfere with natural biorhythms.

VEGA, luminaire created by OMS

Bluelight content



0° – 30° No effect
30° – 45° Unsatisfactory
45° – 90° Good (optimum)
90° – 180° Not desirable (risk of glare)

Correct content of the blue part of the spectrum as close to the sunlight as possible is vital for human comfort. As the discovery of the new photoreceptor that influences the production of melatonin by George Brainard shows, the receptor is especially susceptible to the wavelength of 464 nanometers in the blue part of the visible spectrum. From the evolutionary point of view, blue light, especially prominent during the daylight, signalizes to the body the very fact that it is day and not night.

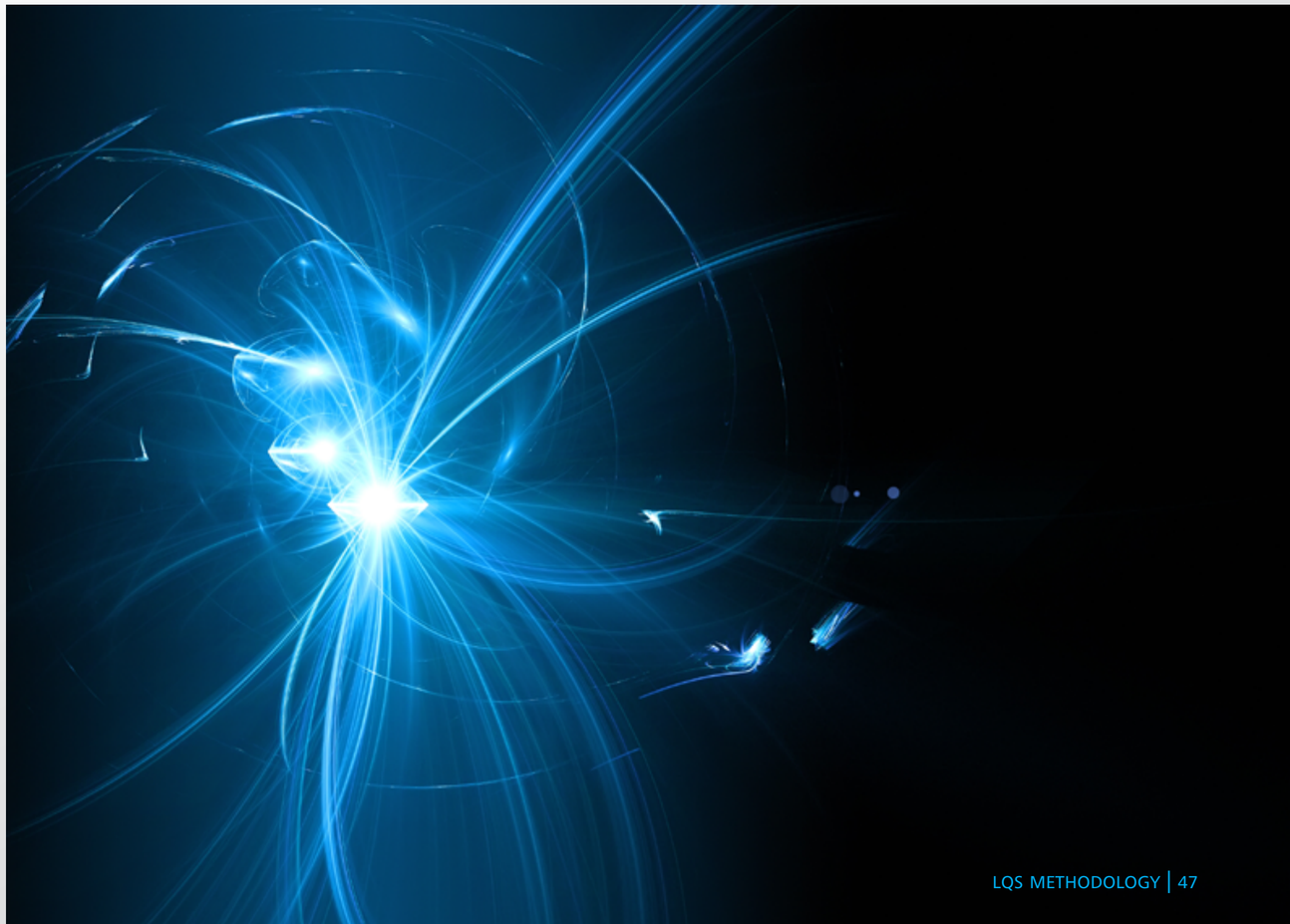
For environments that do not provide adequate access to daylight the blue light content is especially important to comfort and well-being of workers. Without blue light of the specified wavelength the body starts producing melatonin, which brings about lower attention and makes people more prone to sleep. As has been mentioned, the blue light should be ideally coming from above, as the photoreceptors are in the lower part of the retina, therefore reacting better to light coming from the ceiling at specific angles.

The absence of the blue part of the spectrum in light can create hazardous conditions in spaces where heavy machinery is operated, like production factories or warehouses. In the facilities which work in shifts the provision of blue light in the artificial spectrum of the lamp can help adjusting to the nocturnal biorythm required for working at night. In simple terms, enough of blue colour in the spectrum makes people less sleepy and more focused. The same goes for mammals, which react to almost the same wavelength as humans, 484 nanometers. Blue light is also important to plants grown in the interior conditions. This part of the spectrum activates their photosynthetic processes. Their growth without enough blue light in interior would be impaired as well.

This scientific discovery can also help people with insomnia, who should avoid luminaires which provide strong blue part of the spectrum in the rooms they are usually sleeping in. There are even light sources specifically designed to filter out blue light for use in the bedrooms or reading luminaires.

The content of the blue light changes during the course of the day, ideally the lighting system should reflect that to provide maximum comfort for the users and not interfere with their circadian rhythms. The tricky part is that one of the sources of blue light are computer screens, making management of blue light content more difficult. However, free programs are available that dynamically correct blue light content coming from the screen depending on the time of day. With the aid of such programs working even late hours does not disrupt the natural biological clocks. In lighting systems this is more difficult to achieve, but it can be done with a combination of a well-designed system and daylight sensors.

Enough of blue colour in the spectrum makes people less sleepy and more focused. The absence of the blue part of the spectrum in light can create hazardous conditions in spaces where heavy machinery is operated.



Daylight simulation

The reaction of the body to the blue light content and other properties of natural light is all a matter of evolution – the artificial lighting has become a reality only 120 years ago with Edison and his incandescent light. Until then, the organisms have been adjusting themselves to the natural light coming directly from above and have organized their daily activities according to the availability of daylight. The discovery of cells affecting melatonin production has made a significant breakthrough in understanding the role of lighting in human well-being.

Further research even proposed the metric to evaluate melatonin suppression by different light sources, enabling quantitative assessment of different lighting solutions on human behaviour and well-being (Dietrich Gall: Die Messung Circadianer Strahlungsgrössen, Technische Universität Illmenau, 2004). These discoveries have been judged as a new paradigm for lighting systems and their effect on human health by scientist Marc Rea.

For luminaire to achieve full effect it has to be able to supplant daylight not just in illumination of a given space, but in all of its biological purposes as well. Dynamic lighting systems are especially effective in delivering the desired effects. The better the system is at replicating the various aspects and effects of natural light, in stimulating the circadian ganglion cells, the higher it should rank in the emotion aspect.

In spaces with access to natural light the artificial system should play a secondary role: helping to illuminate room in the mornings and evenings or improve lighting conditions in overcast weather or short winter days. The daylight sensors can provide dynamic information about the amount of daylight hitting important areas – such as working surfaces – and in case of insufficient daylight the artificial light should take care of the situation. To prevent sudden changes in illumination levels the switch between natural and artificial light could be gradual, giving the eye enough time to adjust to the new conditions. Such use of daylight is also energy efficient.

In spaces with limited or no direct access to natural lighting extreme care has to be taken to replicate the daylight conditions to the largest extent. This may mean combining different light sources in the luminaires and using digital control of illumination e.g. via pre-programmed scenes for different seasons or times of day. Only in these conditions the long-term comfort for humans can be achieved. Otherwise adverse health effects may occur, from immune problems to depression to insomnia. The evolution still hasn't caught up with the rapid changes in the artificial lighting; therefore new lighting technologies should come to aid to provide the necessary human well-being even in unnatural lighting conditions.

The discovery of cells affecting melatonin production has made a significant breakthrough in understanding the role of lighting in human well-being. The daylight sensors can provide dynamic information about the amount of daylight hitting important areas – such as working surfaces – and in case of insufficient daylight the artificial light should take care of the situation.

Dynamic lighting

Daylight simulation is just one of the applications of dynamic lighting. Even if we don't plan to change colour or angle of lighting, slow cyclical changes in intensity are still beneficial to human mood. A simple automatic system of gradual changes in intensity can improve the perceived quality of space – the changes are similar to those caused naturally by slow-moving clouds. The dynamic part basically means that the lighting is able to change its qualities – illuminance, colour or even angle at which the light hits the eye – over a given period of time based on direct or indirect control mechanisms.

The goal is to, again, provide optimum level of comfort for a given environment and purpose. The secondary benefit is that in some applications of dynamic lighting energy saving can be achieved by e.g. dimming of light. Light sources working below their maximum can also enjoy longer lifespan, adding to the savings.

The simplest way of affecting lighting is by dimming, which in its basic application lowers voltage for the light sources, decreasing their luminous flux. Newer light sources require more complicated approach, where voltage stays the same but current is adjusted. Diming can be done for different purposes: to decrease eye strain, allow for other source of light to take prominence – a projector or a TV, for example – or simply to provide a base level of illumination intensity necessary for security cameras to function.

More sophisticated dynamic lighting systems usually require a certain level of automation: color mixing via RGB LED elements calls for either a remote control or a pre-programmed sequence to be run. The dynamic colour effects are specifically a domain of LED, more traditional types of light sources are unable to mix their spectrum in a smooth way.

The dynamic lighting allows for dynamic use of the rooms: for example, different ways of illumination can be set up for a room that is used both as a leisure space and a home office. The office use calls for correct illumination of the workspace and biologically accurate replacement or addition to natural light. The leisure activities can then do with warmer, more subdued lighting in preparation for sleep. In small apartments with multiple different uses the dynamic lighting can improve both working performance and ability to relax if the system is correctly designed.

The effect of increased performance is even more important for larger office spaces, where a correct mixture of natural and artificial light has to be maintained throughout the day. Sub-optimal lighting can lead to eye strain and other health problems if not corrected. Moreover, the office spaces themselves can become more flexible in their use; turning ordinary workspace into a conference room should the necessity arise. The dynamic lighting system can then allow for presentation to be screened through a projector, an action that requires different lighting conditions than work. In dedicated conference rooms different lighting is required for company meetings and meetings with clients: the former should bolster performance, while the latter should evoke hospitality and positive mood.

In the case of larger lighting systems, the remote controls should be replaced or aided by daylight sensors to keep the light from different sources correctly balanced. If necessary they should be interconnected with shutters if too much direct sunlight is coming in at wrong angles, causing computer screen glare and other unwanted effects.

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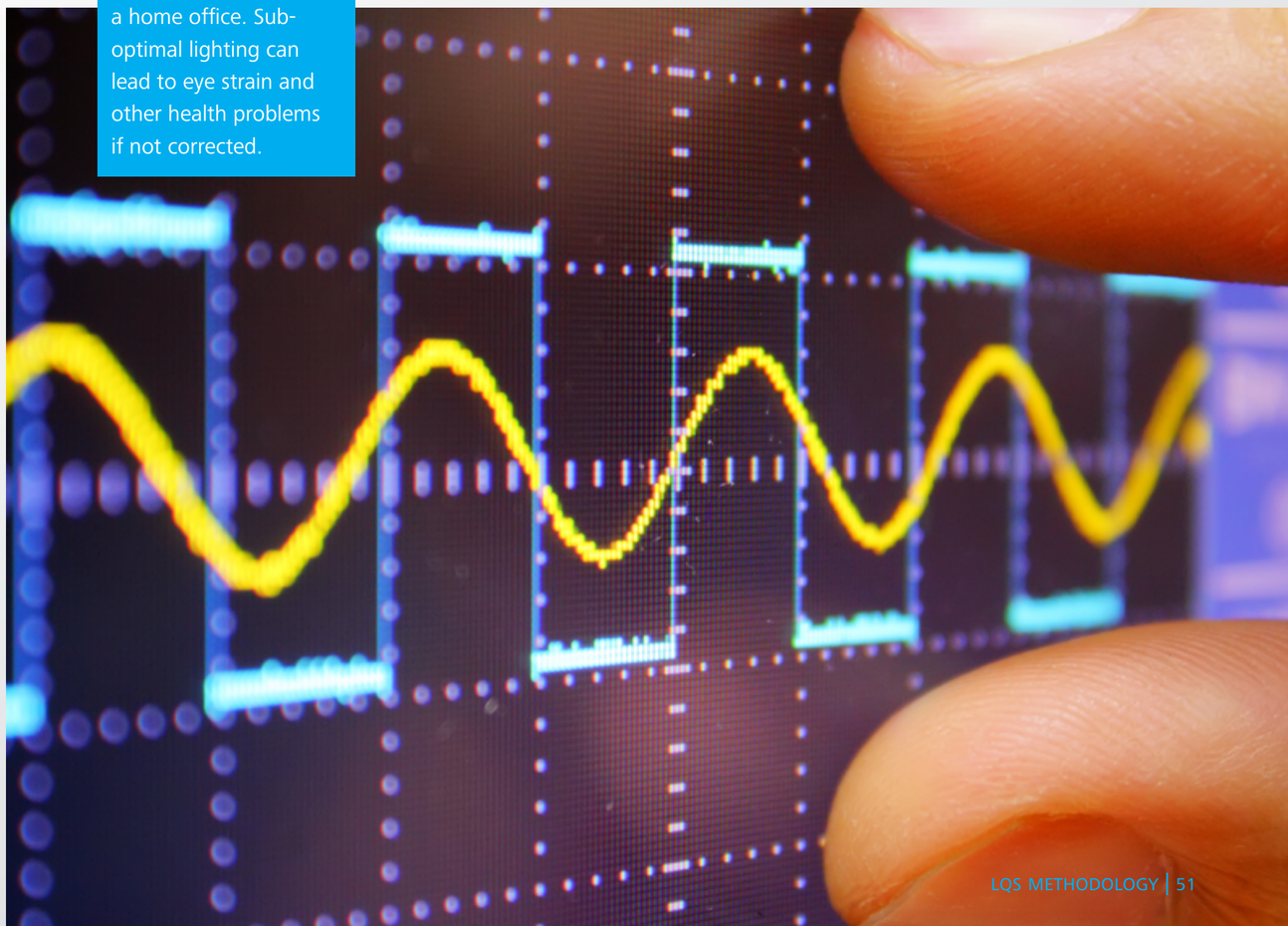

Tunable white

With the introduction of LED technologies the designers got their hands on the possibility of setting the quality of the white light itself. While LED technology offers many opportunities to mix different colour shades from RGB elements, one should not overlook the often neglected fact that white is also a colour. The ability of intelligent drivers for the LED technologies allow changing the correlated colour temperature of white, usually in the range from 2700 K to over 6 500 K or warm to cool spectrum.

This has many different uses: it can help increase productivity in the workplace, help the flow of customers in the retail environment or provide comfortable atmosphere in hotel lobbies. In the retail, residential and shopping applications the correct white tune can help drive the sales. The baked goods show the best under warm lighting, inviting a customer to buy them and suggesting freshness and positive mood. The jewels and precious metals, on the other hand, show the best in cold colour mix, underlining the shiny glitter of the metals such as silver and gold and showing the brilliant cut of gemstones used. Such lighting suggests luxury and high quality.

All these effects can be dynamic: lobby lighting can be changed to business setting from a leisure one and retail outlets can vary the warmth of their white light according to the seasons. In workplace different settings of white can be used during lunch hour, providing a relaxing atmosphere, while working conditions might demand a different setting, one that e.g. correctly renders colours. This is especially important in spaces such as museums and galleries, where natural colour rendering is a priority.

Extremely high-quality colour rendering under LED lighting of over 90 CRI (Colour Rendering Index, a way to compare quality of rendering under different light sources) is still difficult to achieve, but the newest LED technologies are tearing down even this barrier with CRI as high as 95. Other light sources should therefore be considered when extremely correct rendering is required, reducing the option to tune white to simple dimming – or changing the light source for a different one with desired qualities.

For optimum performance technology must be employed that ensures consistency in the required white hue over time. The LED quality can deteriorate during its lifetime and colour sensors could help to detect such deterioration. While replacing conventional light sources with LEDs can sound expensive – after all, replacing the standard halogen bulbs with LED equivalent is indeed a costly proposition – there are benefits to consider.

First, to change the white colour does not require changing the light sources themselves, just tuning them as desired. As this change may cause increased sales or work performance, the investment pays itself off in increased revenues. The system has to be set up correctly, though, and closely monitored. In the case of upgrading the lighting system, a simple change of light sources is insufficient – the system has to be designed from scratch to fit the desired use and required illuminance levels.

Larger installations with LEDs have to find a way to manage heat properly, making LED-only solutions more accessible to new environments rather than renovated ones. LED-only lighting can now closely emulate the natural visible spectrum with very high CRI. This is done by adding those parts of continuous spectrum which are missing, creating a deluxe version of standard white lighting.

LQS value

Biological factor of illumination

Biological factor of illumination	Availability	LQS Value
availability of daylight	No/Yes	0/1
blue light content	No/Yes	0/1
daylight simulation	No/Yes	0/1
dynamic lighting	No/Yes	0/1
tunable white	No/Yes	0/1

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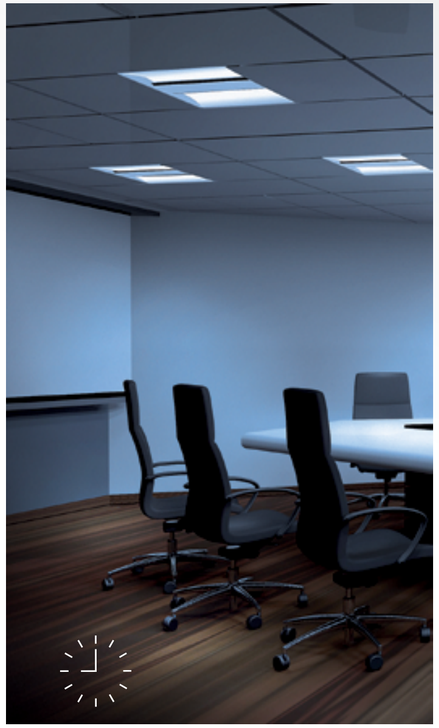

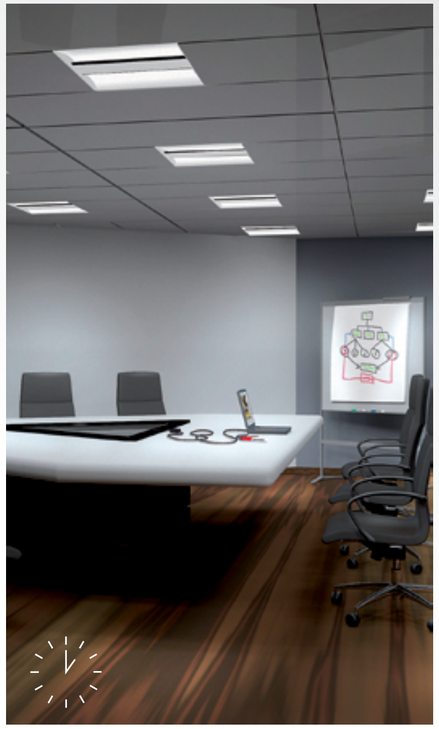

Illumination of room surfaces

Vertical illumination

Ceiling illumination

The recommendations for illumination of surfaces are tied to the working plane illumination. For example, if a required illuminance of a workspace is 400 lux, the walls should be at least 200 lux and ceiling 120 lux on the average. With much lower values on room surfaces the walls and especially the ceiling would feel relatively dark, causing uneasiness or feelings of oppression in the occupants. This factor is important to keep in mind with ceiling heights different than the standard 2.4 meters.

LG7 guidelines, which contain recommendations for interior lighting and design, offer different values of illuminance for different ceiling heights to help achieve optimum illumination. The industry standards call for adequate illumination of working environments. Industry norms set up in European norm EN 12464-1:2011 state basic rules for illuminance of the task area, demanding the lighting to be uniform and the changes in illuminance in the surrounding area gradual and not sudden.

LQS goes beyond the norms. It demands correct lighting of work surfaces, where correct reading, colour rendering and other recognition and visual activities are of paramount importance. Even if the room itself is lighted correctly, the obstruction to light on work surfaces themselves can cause eye strain and further health problems. In such specific cases the LQS calls for asymmetric luminaire with non-standard reflectors for the light to correctly reach surfaces.

Special optical elements can be used to achieve the desired goal. Where necessary, a colour mixing or tuning of white can take place, usually via digital control. This is to make sure that each working space is correctly lighted.

LG7

In the office space lighting, the usual standards are set up in the so-called LG7: lighting guide for office spaces. This standard calls for taking into account both direct and indirect light sources and reflected light. It also sets up recommendations for room surface reflectance and illuminance levels. Although luminaire producers can claim LG7 compliance, the guide is aimed at interior designers: only they can guarantee that the lighting used is indeed LG7 compliant.

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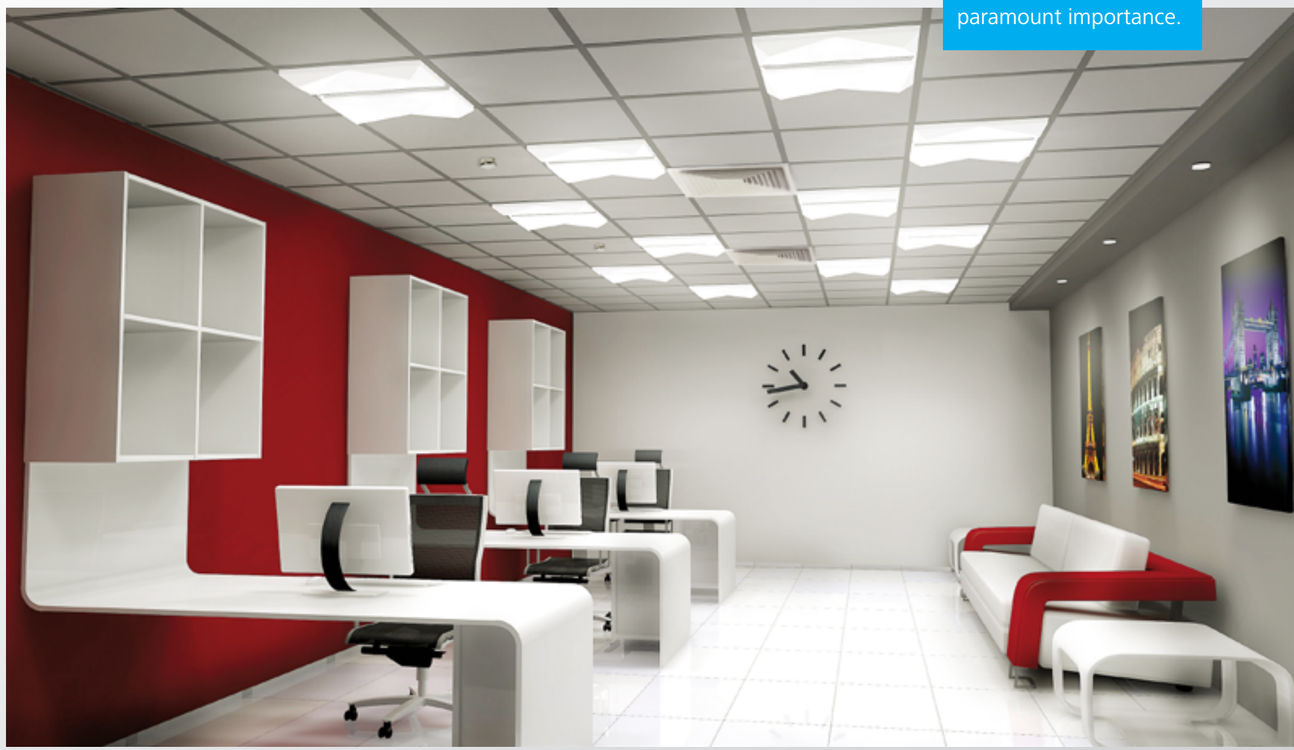


Terzo, luminaire designed by OMS and Giugiaro Architettura

Vertical illumination

Very important part of room lighting is the vertical illumination, reflecting the habit of an eye to react to sunshine and daylight coming from above. With correct vertical lighting a person feels safer and fares better at recognition of shapes and faces. The diffused light reflected from the walls adds to this feeling. The usual standards do not take soft diffused and reflected light into account. Horizontal illumination is not perceived as strongly by a human eye and therefore is much less important to human well-being.

From the LQS point of view it is not important how the full effect of illumination is achieved as long as it is fully present. The types of light sources used do not matter. If the illumination is not sufficient, the lighting solution cannot receive full marks in the LQS rating. The vertical spaces have to be lighted sufficiently enough to make the occupant feel comfortable.

For the correct light to be used when working it is important for walls to be of white colour, otherwise the reflected light would take on different properties than normal light. For LQS purposes only full illumination effect awards the highest marks.

LQS value

Vertical illumination

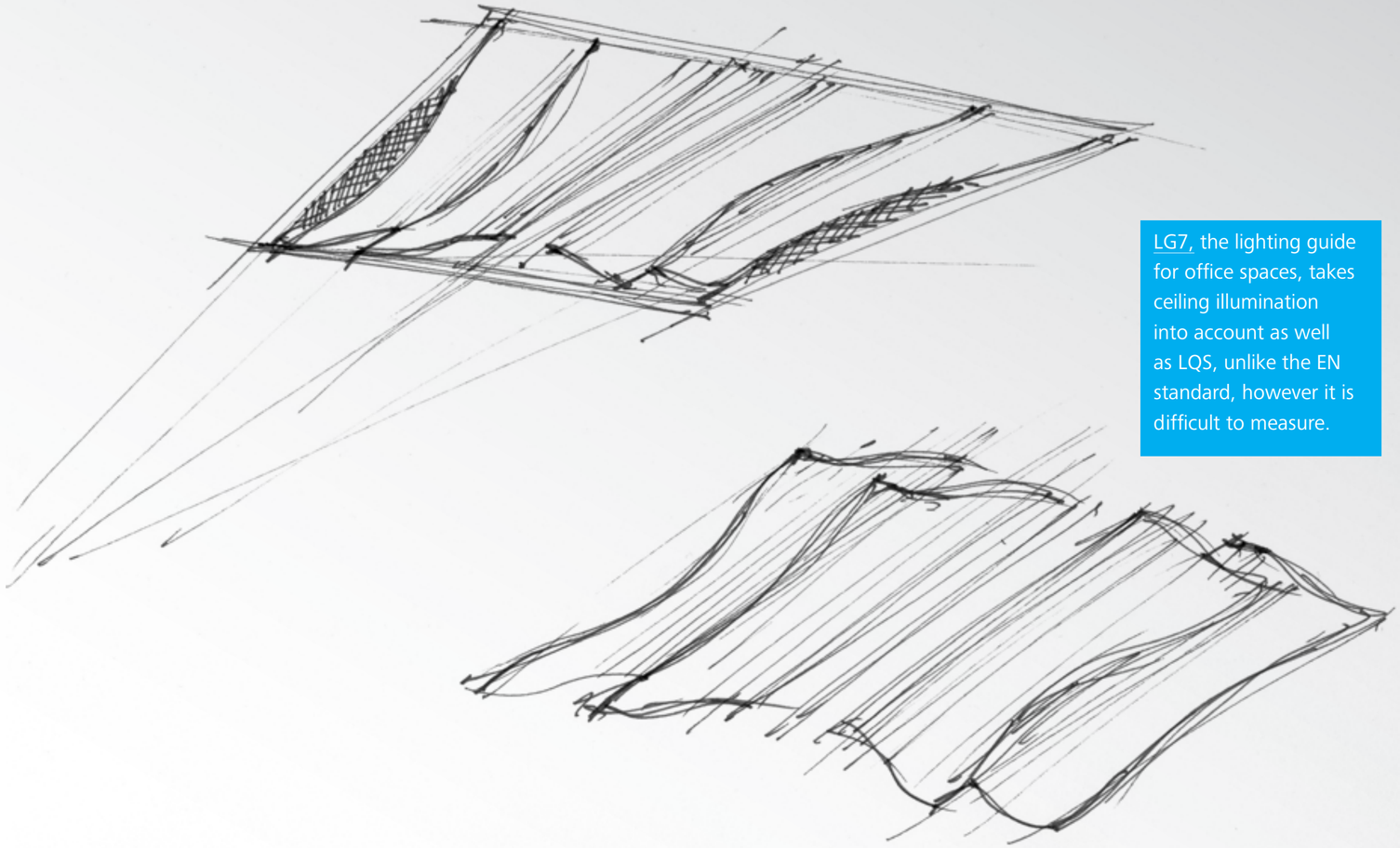
Vertical illumination	LQS Value
Evavg > 0,5Ehavg (WALL LG7) and Evavg>150lx	5
Evavg > 0,5Ehavg (WALL LG7)	4
Evavg > 0,4Ehavg	3
Evavg > 0,3Ehavg	2
Evavg > 0,1Ehavg	1
Evavg < 0,1Ehavg	0

Ceiling illumination

From the point of view of large surface area of reflected light and the desire for the light to come from above it is sensible to actually illuminate ceilings, even though there is no significant action taking place on the surface. This approach creates a very homogenous illumination, although care has to be taken to avoid too high a luminance, over 1500 candelas per square meter. Too high a luminance feels unnatural and can cause glare. In ideal case the cut-off angle of a luminaire is very small and therefore the shift from illuminated areas into dark is soft and gradual. Using an internal reflector and a diffuser is a good idea in this case.

LG7, the lighting guide for office spaces, takes ceiling illumination into account as well, unlike the EN 12464-1 standard. It is difficult to measure, but it can be achieved using a luminance meter and repeated measurements in different spots to get an average value. Such measuring, especially over a large area, can take several hours, but it can be done. It is necessary to do only once and can bring long-term beneficial effect stemming from a correct set-up of ceiling lighting system. A computer program can help calculate the effect of ceiling illumination.

LQS also goes beyond standards in demands for illuminance. Where norms see 30 or 50 lux as sufficient, we propose 75 lux as the new standard and a requirement to achieve the highest possible ranking in this category.



LG7, the lighting guide for office spaces, takes ceiling illumination into account as well as LQS, unlike the EN standard, however it is difficult to measure.

LQS value

Ceiling illumination

Ceiling illumination	LQS Value
Ehavg (ceiling) > 0,3 Ehavg (Ceiling LG7) and Ehavg (ceiling) > 75lx	5
Ehavg (ceiling) > 0,3 Ehavg (Ceiling LG7)	4
Ehavg (ceiling) > 0,2 Ehavg	3
Ehavg (ceiling) > 0,15 Ehavg	2
Ehavg (ceiling) > 0,1 Ehavg	1
Ehavg (ceiling) < 0,1 Ehavg	0

Emotional lighting

RGB colour mixing

Accent lighting

Ambient lighting

This category comprises two different types of lighting that can be considered polar opposites. On one hand it is accent lighting, on the other an ambient one. Both have their applications in interior design, to enhance mood or atmosphere or focus attention on certain details. The human eye reacts differently to different brightnesses, contrast between them – a simple white light can feel warm or cold depending on the light source used. It can be tuned using modern technologies to affect the mood in a certain way.

Emotional lighting can be used to great effect in retail spaces, to provide feeling of additional security in airports and in other uses. In office space good emotional lighting can help achieve understanding in conference rooms when dealing with clients or colleagues. Emotional lighting is finding its way into home electronics as well, becoming a part of TV sets and home theatre set-ups, hoping to increase immersion for movies or video games. They are usually conceived as dynamic systems, changing colours or intensity according to the scenes taking place on the TV screen. With RGB LED technology, emotional lighting can achieve great effects at very low energy consumption levels.

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STARTRACK,
luminaire by OMS

RGB colour mixing

The traditional light sources – fluorescent and incandescent – have their colour light and temperature given by their physical properties. In their case the possibilities of RGB mixing are very narrow compared to LED technology. The LED arrays does provide this possibility and the designers should be able to use the colour mixing to the highest possible extent to accentuate the desired effect.

The RGB mixing uses the simple theory of additive colour mixing: the intersection of the colours creates new secondary colours while the combination of all three makes a white. Different combinations allow for different results in the colour spectrum.

The rapidly developing technology and advances add to the traditional RGB mix to provide even fuller light and remove drawbacks of the traditional RGB combination. The newer elements add amber LEDs to the mix, providing warmth. The other possibilities are white LED elements, including tunable white for different purposes. The effect of the new advances depends on the ability to mix in the new elements correctly for a given purpose.

Amber LEDs for example are less pronounced than the basic RGB, making the colour mixing trickier. Too strong whites can make the light seem too harsh and artificial and that is not always a desired effect. In RGBW elements extra white LEDs are used, allowing to achieve higher quality mixing and ability to provide pastel colours.

Moreover, the dynamic control of the lighting can change according to the season, purpose or time of day. The lighting in the bar for example can provide intimacy one evening and strong, brave colours during the disco night next evening. The shops can choose their colour mix according to the type of the clothes collection currently being sold. Even the white colour can be set up differently according to the requirements of a given locale. The same dynamic effects can be used in domestic environment, ranging from pure illumination to decoration to mood setting, with a very simple control system.

From a ranking point of view, RGB mixing in administrative environment is either present or absent and therefore can only reach either zero or maximum rating. No in-between steps are possible as this is a binary choice.

The RGB mixing uses the simple theory of additive colour mixing: the intersection of the colours creates new secondary colours while the combination of all three makes a white. Different combinations allow for different results in the colour spectrum.

LQS value

RGB colour mixing

RGB colour mixing	LQS Value
Yes	5
No	0

The rapidly developing technology and advances add to the traditional RGB mix to provide even fuller light and remove drawbacks of the traditional RGB combination.

Accent lighting

While overall room illumination is able to set the mood for a given space, the role of accent lighting is to create hotspots in the room that attract attention and enhance details that could otherwise go unnoticed. In the case of these luminaires, the diffusion and the light coming from above is given up to focused, directional light.

Rather than using diffusers, the luminaires aiming to provide accent lighting rely on reflectors and optics to provide a coherent beam of light that should focus on specific objects or spots in the room. It can blend with overall illumination and only provide extra boost of lighting to certain parts of the room, for example to accentuate highlights.

The other purpose can be a safety one, to attract attention to hazardous spaces or emergency exits. It can also be used in external applications, such as to spotlight certain parts of architecture: a tower clock, perhaps, or to accentuate gilding on a church tower.

For both interior and exterior purposes, colour can play an important part in a desired effect. The light source does not have to be an RGB LED light source, the colouring of the light beam can also be achieved by using coloured translucent filters, either glass or plastic ones. These can be interchangeable too, allowing for more dynamic effects. RGB LED gives the extra flexibility of changing the colour on the fly, creating dynamic effects of colour shifts.

LQS value

Accent lighting

Accent lighting	LQS Value
Yes	5
No	0

For both interior and exterior purposes, colour can play an important part in a desired effect. The accent lighting is, in fact, very important sales promotion tool.

Ambient lighting

The very role of the ambient lighting is to set the mood and tone for the room. Its main characteristic is that it has no visible source. To help it in the mood setting the ambient lighting elements can be used in conjunction with other sensory factors: sounds, haptic feedback such as vibration or temperature and air flow. It can be used to enhance the experience of the home theatre setup with dynamic backlighting of LCD TV screens, for example.

Several manufacturers provide their own ambient lighting solutions, where the colour of ambient light itself is affected by the colours of the scene on TV. The effect is provided by mixing and matching of built-in or external, computer-controlled LED lights. Further elements such as fans are added to enhance video games. These have to support the proprietary technology to fully utilize the possibilities.

In interior design ambient lighting most commonly refers to the possibility of colour mixing, usually via RGB LED lighting. Its aim is to enhance feelings, not to achieve perfect colour rendering or optimal reading environment. Again, the technology allows using digital control to change ambient lighting dynamically to further enhance desired mood of the space. When illumination sensors or timers are employed, ambient lighting can change according to the detected lighting level or time of day. It can for example fade down (or up) when TV screen is turned on in an otherwise dark room.

In interior design ambient lighting with hidden light sources can be used in recessed ceilings, allowing the refleced light from the ceiling to replace direct light. The same can be done in walls: recessed niches with quality luminaires installed are able to draw attention to certain parts of the room while luminaires remain hidden from normal view. Recessed ceilings are often used when renovating older buildings for either office or living purposes.

While lower ceiling height is primarily used to decrease heating costs and hide technical installation, the construction is flexible enough to allow for modern lighting systems. These can cut down energy expenses even further.

The ambient lighting in ceiling can be used for illuminating the whole space or just parts of it, if the area is too large or separated into spaces meant for different uses. In wall niches RGB LED elements can be used for great effect, as they can provide bands of continuous illumination. If fluorescent lights are used for this purpose, they have to be separated creating uneven lighting. LEDs have no such drawback.

LQS value

Ambient lighting

Ambient lighting	LQS Value
Yes	5
No	0

Ambient lighting most commonly refers to the possibility of colour mixing, usually via RGB LED lighting. Its aim is to enhance feelings, not to achieve perfect colour rendering or optimal reading environment. The technology allows using digital control to change ambient lighting dynamically to further enhance desired mood of the space.

Ecology

Ecology

Latest lamp technology

System efficiency of luminaire

Thermal output of lamp

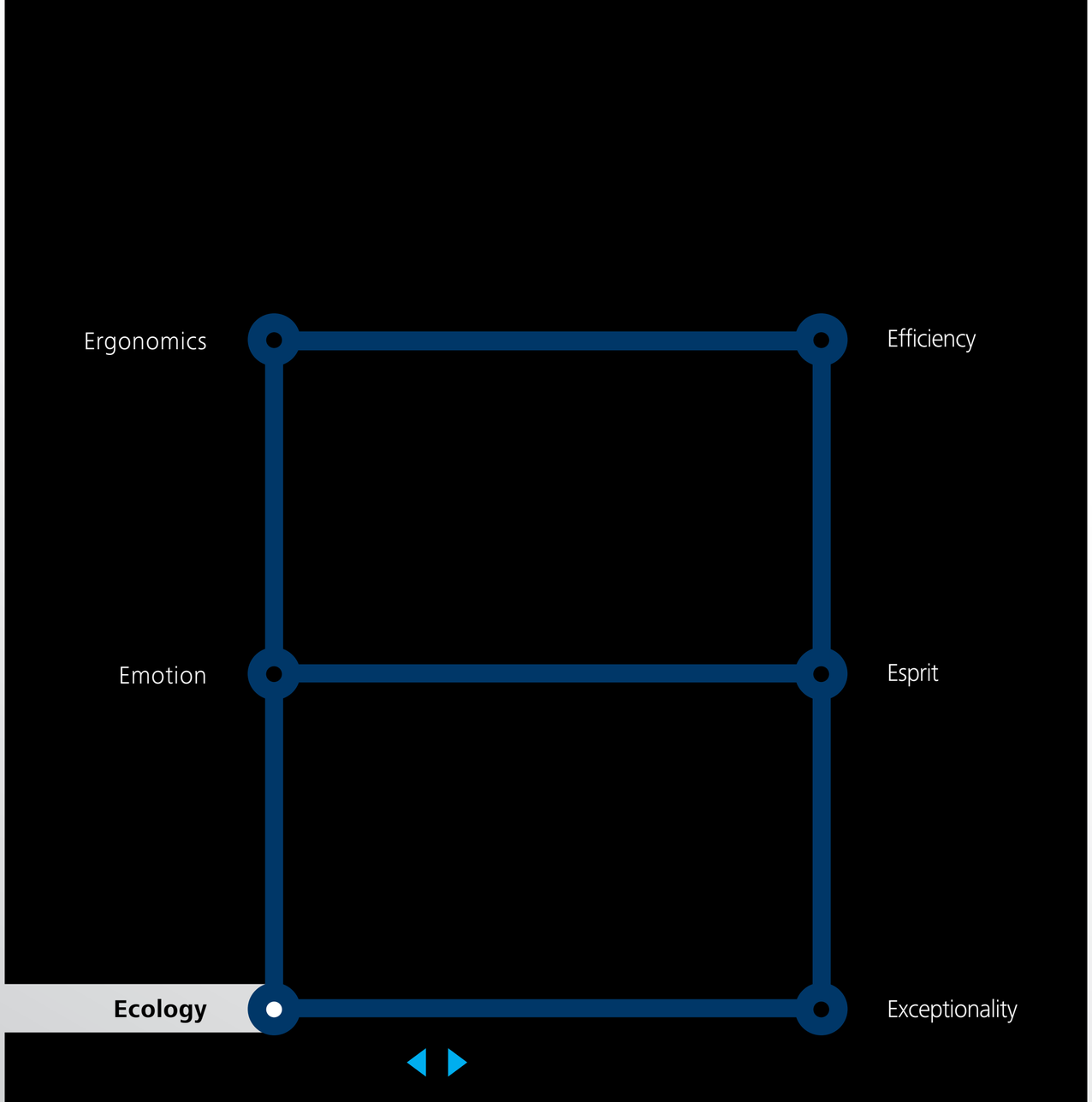
Dangerous material content

Product life-time and maintenance

Control the energy consumption and environmental impact of light usage.

The conversion of energy into the light measures an effectiveness of the lighting source. This can be used for increasing product lifespan while lowering the maintenance costs.

The key Is 6 E's



Illumination is a field that allows for huge ecological advancements, usually by replacing lamps, employing sensors that decrease illumination according to amount of daylight and using a plethora of other new technologies.

Green is not just a colour nowadays; it has become a policy, a way of life and one of the most rapidly developing sectors in the whole industry. Producing "green" - that is, ecologically friendly – products is demanded by clients, supported by markets and perceived as excellent way to improve company brands.

It is not just a hip trend that will slowly fade away. All the aspects of ecological production and consumption – energy efficiency, recyclability, longer lifetime of products – are becoming a major factor in cutting costs in the companies and households. Illumination is a field that allows for huge ecological advancements, usually by replacing lamps, employing sensors that decrease illumination according to amount of daylight and using a plethora of other new technologies.

Chief ecological advance in illumination industry is the current rise of LED technology: it does not contain toxic metals, is extremely efficient and very flexible.

Latest lamp technology

Everyone knows Thomas Alva Edison, the man who discovered a lightbulb. His discovery quite literally changed the way of life. The evolution of lamp technologies has not stopped there. After Edison's incandescent lights there came fluorescent lamps, halogen lamps and their new and more efficient artificial light sources. Public does not know the names of their inventors; Edison is still the father of artificial lighting.

One of those inventors is Nick Holonyak. In 1962 he discovered a first light emitting diode (LED). At that time no one would believe that his discovery would mean a revolution in the lighting world half a century later. Except Professor Holonyak, that is: in 1963 in an article for Reader's Digest he ventured a prediction that LEDs would become of such a high quality and efficiency that they would replace light bulbs in the future.

LED technology is not used solely in lighting industry; it found a wide array of application in electronics and electromechanical industries. The conventional light sources are still present in the majority of luminaires and do not plan to leave prematurely. Not even the developers are able to predict when and how would the LEDs overtake the lighting market.

The last decade saw the descent of incandescent lamp, increasing the evolution of other types of lighting. LEDs will play a significant part in this process. „We are LED optimists. We believe that the future of artificial lighting will be led by LEDs," Miroslav Masár, Director of LED Department of OMS says.

In general, lamps generate light either by thermal radiation or by gas discharge, the radiation of which is either directly visible or is made visible by luminescent material. Incandescent lamps use thermal radiation; fluorescent lamps belong to gas discharge category.

The main parameter here is the luminous efficacy of the light source. It shows how much light it can produce from a given amount of electric energy. Its unit is lumen per watt. The less lumens per watt are produced, the more energy is wasted e.g. through infra-red radiation.

The lighting world is changing dramatically in the past years. Just three years ago the most modern and efficient lamp was a metal halide one. Currently the top of the line belongs to LED lamps – their quality is on the rise while energy requirements are decreasing. Energy consumption is of utmost importance nowadays, as energy prices are climbing constantly. LEDs can help with that: not only are they very efficient, but they produce negligible amount of heat, allowing energy savings on air conditioning as well. Approximately 90 percent of all improvements are currently happening in the LED category. The rest are improvements to fluorescent lamps to increase their shelf life or make them more ecological by creating new technology that allows the use of less mercury. To provide new light sources even for older luminaires, retrofitting is often used – a fluorescent or LED lamp is set into a traditional screw mount of incandescent lamp. Such retrofitting can include the whole electronic driver necessary for LED light.

The advances made in the lighting field are not limited only to new types of lamps. The scientists started to study influences of light on human behaviour, deeply impacting the lighting industries. Special lamps producing continuous spectrum as close to natural light as possible, daylight sensors and control systems that enhance daylight in the environment, even cyclic dimming and brightening of lights to mimic clouds moving in the sky – all of these are practical applications of the scientific discoveries made in the last decade.

LQS value

Latest lamp technology

Latest lamp technology	LQS Value
η>100 lm/W	5
η>90 lm/W	4
η>80 lm/W	3
η>70 lm/W	2
η>60 lm/W	1
η>50 lm/W	0

Energy consumption is of utmost importance nowadays, as energy prices are climbing constantly. LEDs can help with that: not only are they very efficient, but they produce negligible amount of heat, allowing energy savings on air conditioning as well.

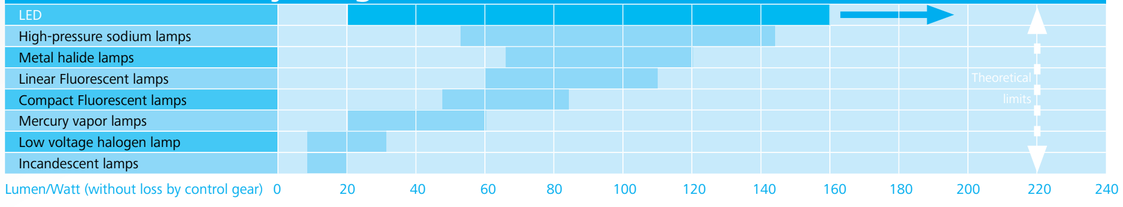
Cube, luminaire by OMS

The discovery of special photosensors in the eye that control the production of melatonin and influence human biorhythm led to designing lamps that better mimic blue spectrum of the sunlight. Blue, the colour of the sky, is the colour that the new photosensors are sensitive to. This knowledge, as was mentioned previously, can be used in the whole new area of biologically active illumination: it can improve focus in schools, performance at work or even mood outdoors, through street lighting.

They are finding a new role in navigating the cities, lighting footpaths at ground level or illuminating fountains, statues and landmarks, affecting mood of the people. Even the white light itself can be tailored to the specific requirements of the environment: white with low colour temperature feels hospitable and inviting and is perfect in pedestrian-only environment, such as city downtowns, where it creates an atmosphere of relaxation.

The increased pressure on energy saving can be felt everywhere. This is what LQS takes into account when judging the lamp technology used. The luminous efficacy of the light source basically shows how much of the energy is turned into light. The full marks are received for luminous efficacy of over 100 lumens per watt. Such high parameters can be achieved by LEDs, ecological fluorescent lamps and low pressure sodium lamps. Due to the fact that LEDs are still being researched and further optimized, their efficacy will be growing in the coming years.

Luminous efficacy of light sources



The increased pressure on energy saving can be felt everywhere. This is what LQS takes into account when judging the lamp technology used. The luminous efficacy of the light source basically shows how much of the energy is turned into light.

CANDLE

INCANDESCENT BULB

MERCURY/FLUORESCENT LAMP

ECO FLUORESCENT LAMP

LIGHT-EMITTING DIODE (LED)

System efficiency of luminaire

This factor depends on the light output ratio (LOR). This is calculated as luminous flux of the luminaire to the sum of luminous flux of all its light sources. For standardization purposes the reference measurements are made in lab conditions, the most important one being a constant temperature of 25 degrees Celsius. The designing of a lighting installation should take this factor into account; otherwise its calculated illuminance values may be incorrect.

The ratio can show how well the luminaire is designed and how much light is lost in its optical systems. The more efficient materials are used the higher the ratio. The shape itself is also very important: correctly designed luminaire reflects most of the lamp's luminous flux into the environment. This is the very core of the luminaire's system efficiency.

The LOR can be further subdivided into upward and downward ratio, each of them specifying intensity distribution of a luminaire in the upper and lower parts of the room. This is important in cases where good ceiling illumination is required. Light output ratio with LEDs is also influenced by heating of the LED elements – a good management of heat in the luminaire is therefore very important.

Light output ratio of luminaire (LOR) takes into account for the loss of light energy both inside and by transmission through light fittings. It is given by the following expression.

$$LOR = \frac{\text{Lumen output of luminaire}}{\text{Lumen output of lamps}} \ [\%]$$

The simple fact that a luminaire is efficient does not automatically mean it is ergonomic as well. Luminaires with high light output ratio can produce glare, which is a drawback when illuminating workplace for example. Typical luminaires with high light output ratio are spotlights and downlights. On the other hand, the luminaires which use specular louvers to prevent glare can provide higher illuminance on the working plane despite lower LOR.

The materials used for luminaire construction are really at the heart of the final light output ratio. Glass, plastics, aluminium and steel all have different light absorbing and reflecting properties. With their proper use as much light as possible can be reflected outside the luminaire and into the environment, providing high light output ratio.

The quality of illumination further depends on how the materials are used. For soft, diffuse lighting the luminaire has to provide material that deflects the light uniformly into all directions, such as matt louvers. The other possibility is to employ a glass or plastic translucent cover with the surface finish that diffuses the light uniformly into the area. If the desired illumination should be concentrated such as in accent lights, the inner surface has to be designed to reflect the lamp light in a single direction. Modern computer programs can help with designing reflectors for luminaires which provide a desired reflection with little loss to light output ratio.

For the purposes of LQS, the luminous efficacy of a luminaire is used, with the highest marks awarded to those providing over 80 lumens per watt. The number for a luminaire is a product of light output of a luminaire and installed power of luminaire. The higher the efficacy of the source and the light output ratio of the luminaire, the better marks can be scored. This means that along quality luminaire design a correct lamp has to be chosen as well. Judged by their efficacy, the best marks can be achieved by those that emit little radiant heat. The production of heat basically means that energy is not being all converted to light, a sign of inefficacious light source.

$$\frac{\text{System efficiency of luminaire}}{\text{Lumen output of luminaire}} = \frac{\text{Lumen output of luminaire}}{\text{Installed power of luminaire}} \left[\frac{\text{lm}}{\text{W}}\right]$$

LQS value

System efficiency of luminaire

System efficiency of luminaire	LQS Value
η>80 lm/W	5
η>70 lm/W	4
η>65 lm/W	3
η>55 lm/W	2
η>40 lm/W	1
η>30 lm/W	0

The LOR can show how well the luminaire is designed and how much light is lost in its optical systems. The more efficient materials are used the higher the LOR. The shape itself is also very important: correctly designed luminaire reflects most of the lamp's luminous flux into the environment.

Thermal output of lamp

The visible light spectrum is found between ultra-violet (UV) and infra-red (IR) radiation, infra-red being the one with lower frequency. People do not see infra-red wavelengths, but they do perceive it nonetheless in the form of radiant heat. Light sources produce IR radiation, the amount depending on the type of lamp. Any object under direct light is therefore subject to constant thermal stress, which can change its properties.

Sometimes it is a useful feature: strong IR radiators are used in restaurants to keep the food from getting cold for example. A classic source of IR radiation is incandescent lamp, a notably inefficient light source where only 5 percent of energy is turned into light. High pressure sodium lamps, although more efficient, still turn as much as 70 percent of energy into heat, the rest is visible light. The rest is radiated as heat, making this obsolete light source a health hazard if it can be easily reached and touched.

In food stores, clothes shops, pharmaceutical labs the production of IR radiation is usually not desirable and can aid deterioration of goods on offer. Some foods can even be irreversibly destroyed under high radiant heat. For these purposes the new LED technologies can provide light sources of choice due to their minimum IR radiation. It can be said that LED is the only light source that does not negatively affect the qualities of the goods it is illuminating.

High volumes of radiant heat mean another problem to tackle: if luminaires or light sources are used in a closed area the produced heat has to be funnelled out to keep the temperature from increasing. This means higher demands on air conditioning, which itself requires substantial energy consumption. With lighting systems that utilize heat-producing lamps energy costs are high both due to inefficient light sources and the higher load for air conditioning. Not to mention irreparable damage to goods staying too close to a radiant heat source, thus lowering the revenues in retail spaces.

For the purposes of LQS the proportion of IR radiation is assessed across all light sources used and average is made. The amount if IR radiation can be found in documents available from lamp producers. The lower the average proportion of the IR radiation, the better is the mark in LQS. The top marks are given to proportion of IR radiation below 15 percent – a domain of LED-only solutions. The systems with IR radiation share of over 60 percent receive 0 points, showing the wasteful nature of incandescent and many fluorescent lamps.

LQS value

Thermal output of lamp

Thermal output of lamp	LQS Value
<15% proportion of IR radiation	5
<26% proportion of IR radiation	4
<28% proportion of IR radiation	3
<31% proportion of IR radiation	2
<60% proportion of IR radiation	1
>60% proportion of IR radiation	0

High volumes of radiant heat mean problem to tackle: if luminaires or light sources are used in a closed area the produced heat has to be funnelled out to keep the temperature from increasing.

Dangerous material content

When talking about dangers from light sources one usually imagines cutting a hand on broken bulb. This is quite far from the important natural hazards contained in most light sources used today. The problematic parts are heavy toxic metals like mercury and lead. Mercury is a vital part of all fluorescent lights, the neon signs and most HID lamps.

All of these use mercury vapours enclosed in vacuum to provide the lighting itself. When the lamp is turned on, mercury atoms become ionized, producing ultra-violet radiation. This radiation then hits a small layer of phosphorus which covers the inside of the fluorescent glass tube. The phosphorus then emits the visible spectrum.

Lead is another highly toxic heavy metal. It is found in glass used in lamp production as well as a soldering agent in the screw-in bases of both old incandescent lamps and their new, fluorescent retrofitted replacements. Quality soldering of the parts of the lamp is important to keep the vacuum inside the lamp – if tin were used it would turn liquid under high heat produced by the lamp.

Using such light sources then creates difficulties with disposal of used or broken light sources. Special care has to be taken so that the heavy metals do not get into the environment. Mercury accumulates in soils and does not disintegrate or oxidize. From soil it can get into foods, especially root vegetables. High concentrations of mercury can cause hallucinations, delirium and death. Lead has very similar properties to mercury except for being solid instead of liquid at room temperature.

The designing a lighting system that is ecological means choosing the light sources wisely. Newer fluorescent lamps contain less mercury than before, usually signified by using the adjective “eco”. Special care has to be taken when choosing the lamps – lamps marketed as longlife do not necessarily contain less mercury than normal ones. However, neither do they contain more of it.

When replacing lamps containing mercury special care has to be taken so as not to break them. Mercury can be breathed in by the employees, creating an occupational hazard. When removed the lamps have to be disposed of in special collecting centres, not normal waste, increasing maintenance costs. The comparisons show that the most efficient modern lamps usually contain less mercury than their comparable less efficient counterparts, making them both ecological and energy efficient source.

From the point of view of dangerous materials content, LEDs are clearly a winner as they do not contain any mercury at all while being highly efficient. Some of the more advanced ones can contain europium, which is a heavy metal but is considered non-toxic.

LQS value

Dangerous material content

Dangerous material content	LQS Value
mercury content 0mg	5
mercury content <0,5mg	4
mercury content <1,5mg	3
mercury content <2,4mg	2
mercury content <5mg	1
mercury content >5mg	0

The designing a lighting system that is ecological means choosing the light sources wisely. LEDs are clearly a winner as they do not contain any mercury at all while being highly efficient.

Product lifetime and maintenance costs

When incandescent lamps have been phased out one of the reasons for their replacement was much longer lifetime (and higher efficiency) of fluorescent lamps. The fluorescent lamps can indeed last well over 10-thousand hours but older ones deteriorate rapidly when turned on and off frequently. This factor has to be taken into account when designing lighting systems that use fluorescent lamps.

For example, connecting a presence or motion detector to a fluorescent lamp in a corridor (usually to cut down energy costs) might be a bad idea from the lamp lifetime point of view. If the corridor is used intermittently yet frequently, the lamp will demand frequent maintenance and replacement.

LED lighting has none of these drawbacks all the while having much longer lifetime of 25-thousand to over 50-thousand hours. Many of the early LEDs from 1970s are still functional. Failure ratio is also much lower with LEDs than with other lamps. LEDs are solid state light source, meaning that mechanical deterioration does not apply to them.

The maintenance costs do not depend solely on the lifetime of a lamp. It is a significant part of the costs, as newer technologies are more expensive, but it is not the only part. Frequent replacement of fluorescent lamps may also mean smaller revenues: an office or retail space has to be closed down when maintenance and replacement take place.

Heat radiated by fluorescent lamps can also negatively affect lifetime of a luminaire, increasing refurbishment costs. And the fluorescent lamps have to be disposed of safely due to mercury content, requiring yet more effort when replacing them. Again, none of these drawbacks apply to LEDs: maintenance is much less frequent due to long lifetime, they do not require special treatment when replacing them and their heat radiation is negligible.

When designing a lighting solution for a certain environment, all these factors should be considered. An all LED solution might seem costly but it will save maintenance costs. LEDs can be used with automatic controls, reducing the necessity of manual switching, which is yet another area of maintenance. Moreover, LEDs are more energy efficient and can decrease energy consumption even further in conjunction with daylight sensors.

If a fluorescent lamp solution is used anyway one should not forget to add labor costs to the maintenance expenses. During the lifetime of an average LED lamp the fluorescent one has to be replaced two or three times. This requires a janitor, a ladder, correct disassembly of the luminaire, their cleaning, replacing of the lamp, and the re-assembly. In many environments the surrounding area has to be emptied, further adding to the discomfort of the employees. Regardless of having an own janitor or paying for maintenance as an external service these labor costs can be higher than the price of the lamp itself.

LQS value

Product life-time & maintenance costs

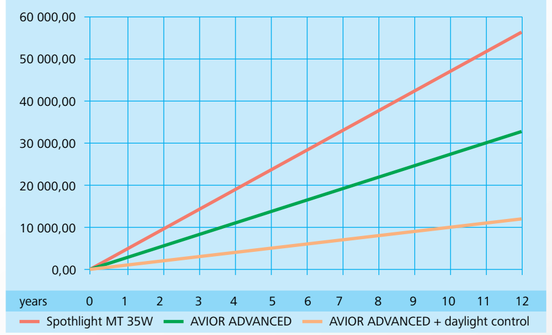
Product life-time & maintenance costs	LQS Value
≥50000	5
>24000	4
>19000	3
>12000	2
>10000	1
≥2000	0

An all LED solution might seem costly but it will save maintenance costs. LEDs can be used with automatic controls, reducing the necessity of manual switching, which is yet another area of maintenance. They are more energy efficient and can decrease energy consumption even further in conjunction with daylight sensors.

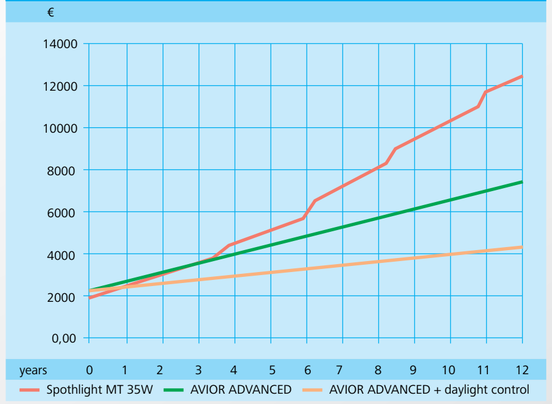
Total costs of ownership (the comparison)

type of luminaire	Spotlight MT 35W	AVIOR ADVANCED	AVIOR ADVANCED + daylight control	
type of lamp	MT	LED	LED	
power consumption	35	25	25	W
number of lamps in luminaire	1	1	1	pc
control gear	ECG	ECG	ECG	
type of lihting control	none	none	light sensor	
life of lamp	12 000	50 000	50 000	hour
power consumption of luminaire	42	25	13	W
luminuos flux	3 500	2 400	2 400	lm
LOR	65	100	100	%
luminaire light output	2 275	2 400	2 400	lm
number of luminaires	20	20	20	pc
average time when luminaire switch on between 6.00 - 18.00	9	9	9	hour
average time when luminaire switch on between 18.00 - 6.00	3	3	3	hour
number of days in week when luminaire switch on	7	7	7	day
price for electrical energy	0,15	0,15	0,15	€/kW/hour
purchase price of luminaire	72	125	125	€
purchase price of light source	25	0	0	€
purchse price of service hour	20	20	20	€
time needed for the exchange of one source	0,25	0,25	0,25	hour
COOLING ENERGY				
Cooling system usage factor	50%	50%	50%	
Cooling efficiency	2,5	2,5	2,5	Wh/Wc
purchace for initial instalation	1 940,00	2 500,00	2 500,00	€
Number of maintenance required per 12 years	4	1	1	
Maintenenace fee	600,00	100,00	100,00	€
power consumption of luminaire	42,00	25,00	13,00	W
power consumption of cooling system	8,40	5,00	2,60	W
completly power consumption of room	1 008,00	600,00	312,00	W
consumption el. energy for day	12,10	7,20	2,86	kWh
month	367,92	219,00	87,12	kWh
year	4 415,04	2 628,00	1 045,42	kWh
production of emission CO2 per year	2 825,63	1 681,92	669,07	kg
price for el. enegy per day	1,81	1,08	0,43	€
month	55,19	32,85	13,07	€
year	662,26	394,20	156,81	€
difference between input cost		560,00	560,00	€
saving difference per year - power consumption		-268,06	-505,44	€
saving CO2 per year		-1 143,71	-2 156,56	kg
payback excluding maintenance		2,1	1,1	Years
payback including maintenance		2,2	1,2	Years

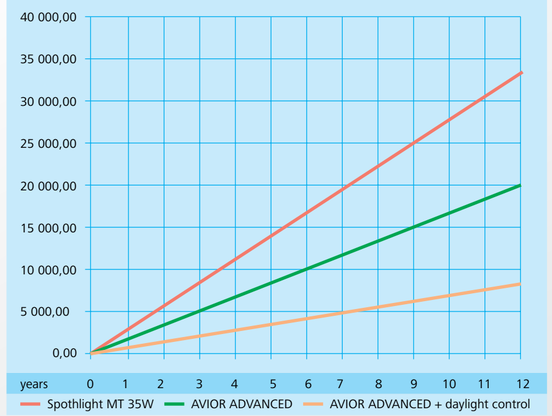
Power consumption of lighting installation



Operating costs and payback time



Production of CO_2



Efficiency

Efficiency

Presence detector

Constant illuminance sensor

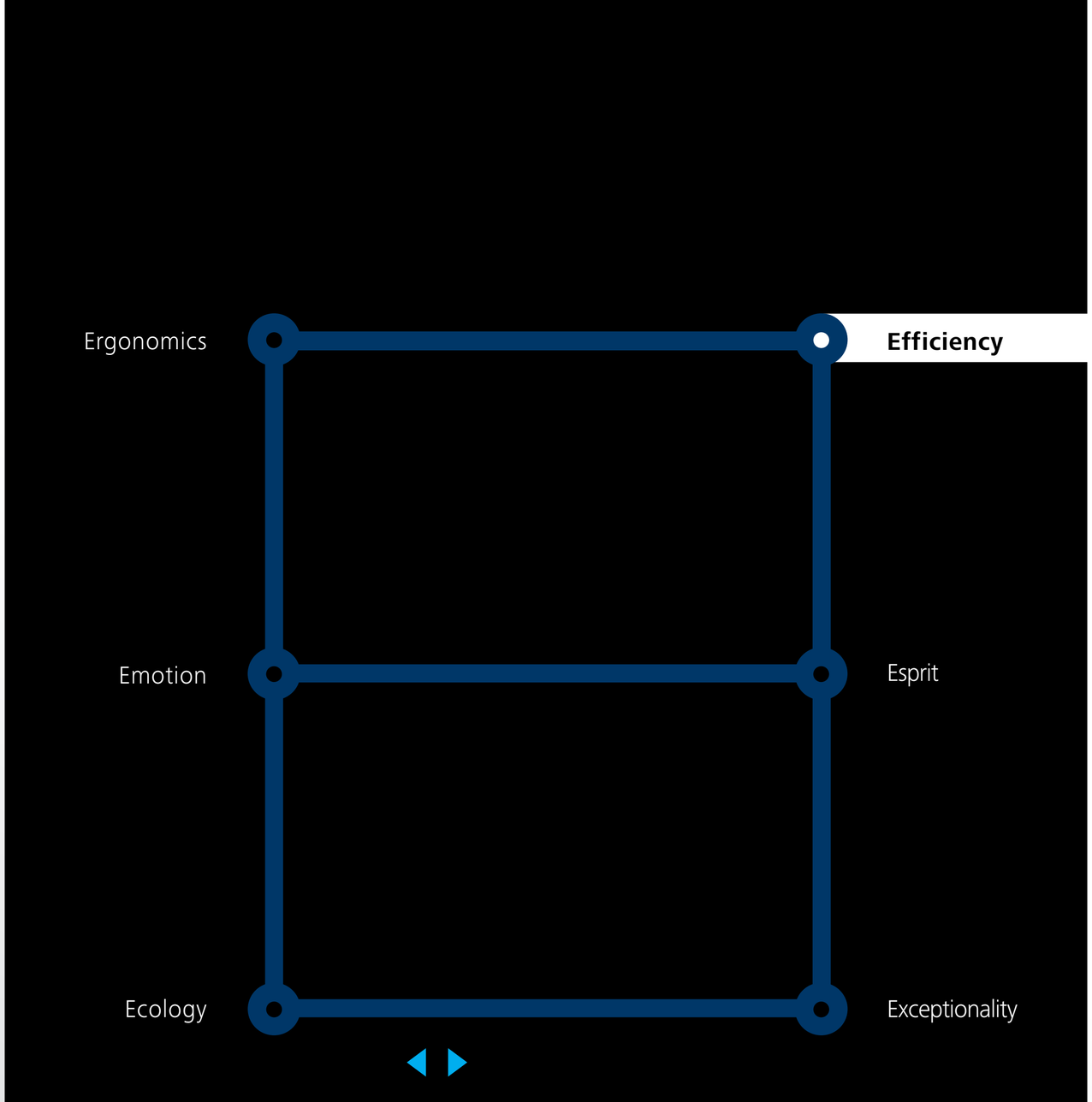
Daylight sensor

Calling of lighting scenes

Take advantage of innovation in control and regulation of lighting.

There are a large number of possibilities to choose the right interface for desired effect of illumination. The decision should be made according to the type of space to be lightened.

The key Is 6 E's



Changing the mood and atmosphere or the light intensity of the room can be as easy as touching a screen of your smartphone.

Take advantage of the current technology progress and use it to your benefit. Harness the natural light to the fullest while enjoying the stable illumination that the modern technologies provide. Changing the mood and atmosphere or the light intensity of the room can be as easy as touching a screen of your smartphone. Whether in working or leisure conditions the newest advances allow you to enjoy optimal lighting while also saving time, energy and maintenance costs.

Daylight is both free and most beneficial to human health; it would be a waste to neglect it in the illumination of the space. The perfect lighting solution can now be literally at your fingertips, providing maximum comfort and saving both electrical and your own energies. Efficiency is now available more than ever before.

Presence detector

The basic premise of the presence detection for illumination purposes is to turn the lights on if and only if the room is occupied by a person and therefore lighting is actually needed. This type of automatic hands-off lighting management combines user comfort with optimizing energy consumption. Its basis is a passive infra-red sensor (PIR) reacting to the heat dissipated by moving persons in an area. Such sensors can be used in both indoor and outdoor application provided their sensitivity is dialled to the desired level. Their height is also important to the correct covering of a serviced area. If ideal coverage is desired, the scanned areas of different sensors should overlap slightly to provide continuous monitoring of the whole area.

The traditional use is in the maintenance or access corridors which do not need to be illuminated continuously. In living areas simple motion detecting PIRs may not suffice – they may trigger the lighting when a person moves, but turn it off once the person remains still, which is not the desired effect e.g. for the living rooms. They also have to be mounted so they would not be triggered by possible strong sources of infra-red lighting, such as street lamps, air conditioning units or heating elements. Such false triggers of PIRs would defy the main purpose of presence detectors – optimizing the energy use by automatically turning the lights on or off without the necessary and often erroneous human interaction.

The total hands-off nature of presence detector is especially sensitive to incorrect set-up: when not installed correctly, it does not turn the light on when necessary, decreasing human comfort level in dark and often unfamiliar areas. In ideal situation the light has to turn on the moment a person enters detector-covered area and stay on as long as a person is present. In spaces where the scanning areas of PIRs may be obstructed by environmental elements a higher density of the detectors is required.

The automatic illumination does not have to be a simple on/off operation. In certain cases a base level of illumination is required, e.g. ten percent of the total level, for basic orientation or functioning of security cameras. Light sources also last longer if they are not turned on and off often, but rather stay on all the time. Especially with modern, more expensive technologies the costs saved in this way can be substantial, outweighing the extra energy spent to keep them turned on at a base level.

While the fluorescent bulbs can seem cheap to replace to take such considerations into account, the heat they produce can create negative external costs e.g. in higher consumption of industrial air conditioning, which has to funnel off excess heat created by less efficient light sources. On the other hand, even LED lamps can now be retrofitted to standard fluorescent luminaires, providing a new level of control of both light intensity and colour.

Once a person enters a scanned area the full level of illumination is activated and can fade down gradually when a person leaves the area or it is turned down immediately. If the time of dimming is time-based the timer has to be set up to leave the lights on for long enough periods to provide a person with comfortable lighting level. The timers are thus usually less efficient than the lighting turned on or off by presence detectors itself, as they are set up to stay on longer than necessary. On the other hand, PIRs by their nature are passive and require almost no energy to operate, making them an extremely efficient element of a lighting system.

LQS value

Presence detector

Presence detector	LQS Value
Yes	1
No	0

The automatic illumination does not have to be a simple on/off operation. In certain cases a base level of illumination is required for basic orientation or functioning of security cameras.

Constant illuminance sensor

The keynote is to keep constant illuminance in a given area regardless of the state of the luminaires. The role of the sensor is to detect the level of illuminance and adjust the output of the lighting system accordingly to reach a preset level. By their nature the light sources are losing their luminous flux during their lifetime, a fact which can be remedied by increasing the total luminous flux in a given space. The illuminance can also be adversely affected by luminaires or their diffusors getting dirty or obstructed.

The role of the sensor is to provide the optimum level of comfort and for this the lighting system has to be designed for its use from the very beginning. The most important part is to provide extra capacity for later increase of the illuminance, when the light sources start wearing out. Simply put, the system should be designed to provide higher illuminance than necessary. While it may look wasteful to use more or stronger light sources than required, the efficiency stems from the fact that they are not working at full capacity most of their lifespan, thus consuming less energy. This design also allows for failures of individual light sources without diminishing the lighting comfort of an area.

Constant illuminance sensor is also extremely useful in combination with daylight sensor. It can adjust the artificial lighting to the light coming through the windows, keeping the level of illuminance constant during the day. This can be important for working with computers for example, to reduce screen glare and other unwanted effects such as insufficient lighting conditions. Both can cause eye strain and can lead to poorer performance and possible health problems. Similar to infra-red presence sensors the placement of constant illuminance sensor is of utmost importance: it has to be free from reflections or strong direct light sources which can adversely affect its readings and functioning.

When necessary, several sensors can be used over a single area. Their individual data can drive independent parts of a lighting system. Alternatively, the system can use an average of their readings to achieve optimum output and performance. In a well-designed system the combination of different sensors can adapt to any daylight condition without compromising illumination quality and comfort of the workers, clients or inhabitants.

Moreover, such set-up is a great saver of energy and lifespan of the artificial lighting, as it aims to use the natural daylight to its fullest. The composition of sunlight is natural for humans, further increasing their comfort levels when it is harnessed instead of replacing it with artificial lighting. The headroom necessary for correct functioning of the constant illumination sensor depends on the types of light sources used, their number, density and also the kind of environment itself and its lighting requirements.

LQS value

Constant illuminance sensor

Constant illuminance sensor	LQS Value
Yes	1
No	0

The role of the sensor is to provide the optimum level of comfort. While it may look wasteful to use more or stronger light sources than required, the efficiency systems from the fact that they are not working at full capacity most of their lifespan, thus consuming less energy.

Terzo, luminaire designed by OMS and Giugiaro Architettura

Daylight sensor

As mentioned previously, daylight is one of the most important agents in human health: its presence or lack affects circadian rhythms and the human eye is used to it coming from above, with vertical illumination providing quicker recognition of shapes and faces. The daylight sensor takes these qualities into account and helps the artificial light to supplant rather than replace the daylight itself. Most environments even if they have access to sufficient sunshine cannot utilize solely natural lighting. The conditions change dramatically during daytime, among different seasons and in changing weather conditions. Sunshine can also have some adverse effects such as creating glare on computer screens, decreasing or preventing their legibility.

Although it seems that the sensor could be replaced with a simple manual dimmer that would be adjusted as needed, such a solution might be cheap but both inefficient and uncomfortable. Human operator is not able to judge the overall illuminance level correctly, leading to either too much lighting and wasting energy, or too little lighting with adverse effects to people occupying the space. Moreover, the illumination changes during the normal course of the day, demanding constant manual adjustments.

Daylight sensors in conjunction with well-designed lighting systems can maximize the qualities of daylight; prevent its drawbacks all the while using the whole system as efficiently as possible without compromising user comfort. The highest efficiency can be reached in environments with ample daylight coming through windows. The intensity of artificial lighting is constantly adjusted to reflect the incoming natural luminous flux. At noon all or most of the illumination can be provided by sun while early or late in the day this function is taken over by the artificial lighting system. The artificial light sources might never fully fade down, as turning them off and on frequently shortens their lifespan.

The daylight sensors themselves work best when communicating with nearby parts of the lighting systems. Unlike PIRs used in the presence detectors their scanned areas should never overlap, as this could lead to instability of the lighting system: constant readjusting of different parts of the system, for example. The sensor itself reacts to the illuminance of the area directly underneath, in optimum conditions this would be the working area, as it requires constant quality of illumination.

The sensor itself should not be placed opposite to the sources of strong light or reflections, such as windows or mirrors, as this would negatively affect its readings. The detection depends strongly on the colour of the area under the sensor, which can lead to extreme circumstances, such as when a book is placed on an otherwise dark wooden tabletop. For such cases the changing of the lighting can be set to happen gradually as to not affect the comfort of the user. Special conditions take place when an environment does not have uniform access to daylight. In such cases the room can be separated into different parts for the purpose of daylight sensors, with their reading differently affecting different parts of the room. In the space further from the windows the base illumination level would always be higher than that by the windows. In case of total darkness outside the illumination level in both parts of a given space would be identical, provided solely by artificial lighting.

Such conditions also call for specific design choices as the demand for artificial lighting would be higher in the space further from the windows. In this space the luminaires might provide less light than by the windows, providing energy savings by letting them work at less than 100 percent. This also improves their lifespan. Daylight sensor is the most energy-saving technology in the efficiency criterion and therefore receives two points in the LQS Value. All the others criteria in Efficiency chapter add just one point to the ranking.

LQS value

Daylight sensor

Daylight sensor	LQS Value
Yes	2
No	0

Daylight sensors in conjunction with well-designed lighting systems can maximize the qualities of daylight; prevent its drawbacks all the while using the whole system as efficiently as possible without compromising user comfort. The highest efficiency can be reached in environments with ample daylight coming through windows.

Calling of lighting scenes

At its most simple, changing the lighting scene can be achieved without any sensors with a simple dimmer. Manual dimming fully relies on the input of the user – it cannot be programmed or preset and only offers hands-on direct management of luminance. It has one huge advantage though – it works with most technologies, can be applied to almost any environment and installation conditions and is cheap. Its main component is a switch that allows turning lights on and off with the separate or combined element that allows for gradual dimming and setting the desired level of lighting. It is available for analog, digital and thyristor lighting control systems.

Even though the low-end dimmers are simple, there is still progress in their construction. Currently the dimmers are built with silicon-controlled rectifiers, which do not dissipate heat, unlike the traditionally used variable resistors. This means improved efficiency of the switch, regardless of the luminaire efficiency. But indeed, manual dimming systems have a distinct disadvantage of relying solely on feedback to a human operator.

Apart from manual dimming there can still be a simple sensorless set-up that provides different lighting levels for different tasks such as work, maintenance, production or night-time security. The pre-set scenes can fade the lights in and out different parts of the space in given increments. The luminaires can be completely turned off or increase their intensity in gradual steps of e.g. 25 percent. Each of these levels would be suitable for different purpose. This allows saving energy in cases where full intensity of luminaires is not necessary.

In more complex applications the lighting scenes can indeed take form of a scene akin to the one in theatre. Leisure time can enjoy different lighting set-up than working, all in the same area. When LED systems are in place, the system can be further enhanced with RGB light mixing, changing the mood of the room, even very dynamically. In such uses the lighting can even be remotely controlled, whether by a dedicated remote control or via a PC, tablet or even iPhone and iPad.

The usual infrared remote controls might not be sufficient in more complicated spaces where direct line of sight between a remote and a sensor might not always be established. In such cases radio control elements might be used, as they are able to pick up a signal even over a wall. This makes them a favoured tool in interior designs where they are required to be hidden e.g. behind a dry wall and still fulfil its function.

LQS value

Calling of lighting scenes

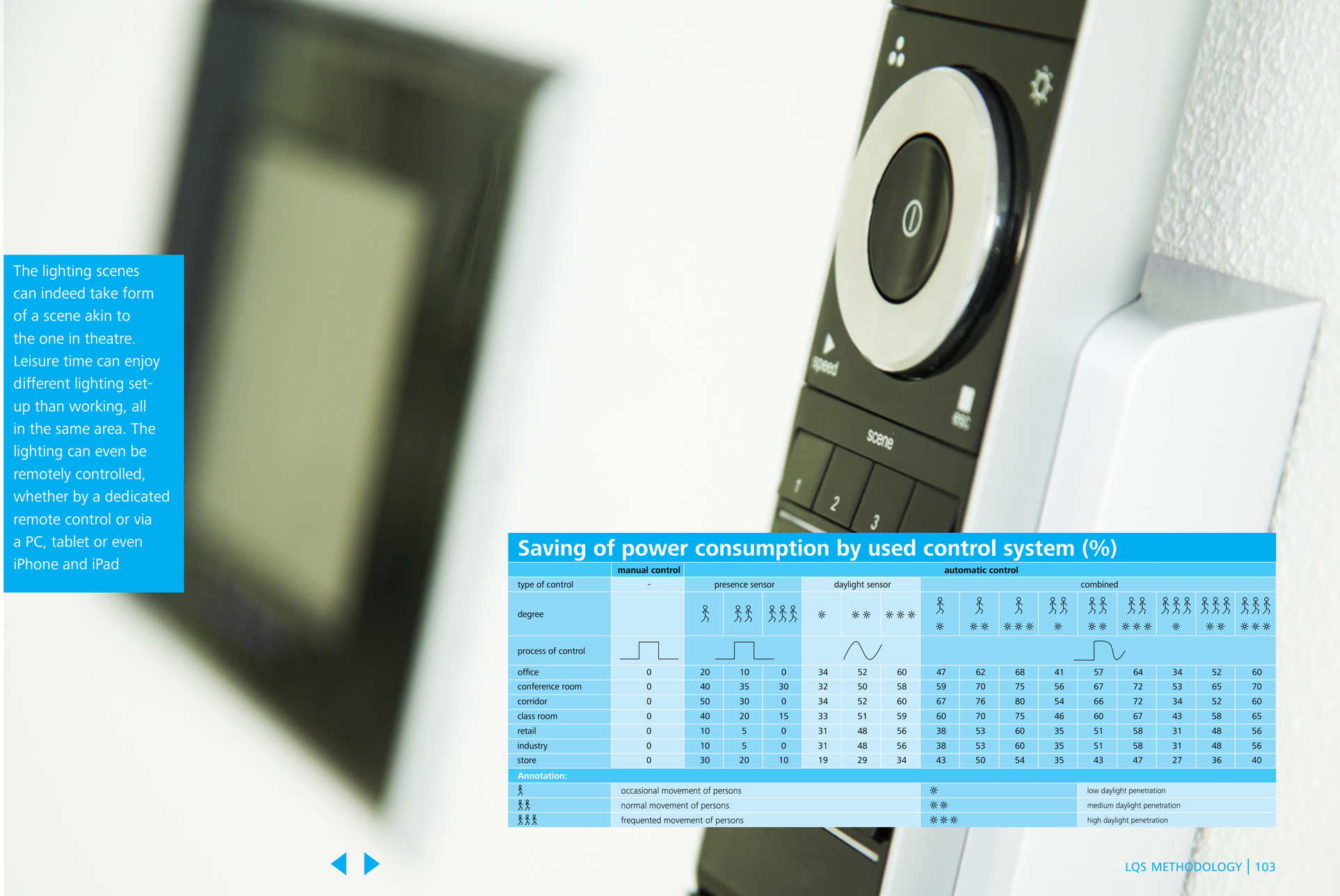
Calling of lighting scenes	LQS Value
Yes	1
No	0

Digitally programmable scenes allow for dynamic changes in the lighting, which can be pre-programmed and preset to happen in specific order and timing, further improving the mood of the spectators.

In the case of lighting systems controlled digitally via DALI or DMX protocols, DALI allows for complex lighting systems programming and combination. DMX is more useful in applications where RGB mixing is required. Both can be controlled over a LAN or a Wi-Fi, which, similar to radio controlled sensors, is available even when not directly visible. Along with controlling and programming the lighting via a PC the remote control function can also be delegated to an iPhone or another Wi-Fi enabled smartphone, given that a proper application is available for a given platform.

Digitally programmable scenes allow for dynamic changes in the lighting, which can be pre-programmed and preset to happen in specific order and timing, further improving the mood of the spectators. Again, the comparison to the theatre is at hand, where modern scene-lighting systems are similarly preset and pre-programmed for every performance taking place and saved for re-use. Latest lighting controls based on DALI protocol can be preset to 128 different scenes and can control up to 16 thousand combined groups of elements, which can include not only lighting, but also electrically controlled window shutters, air conditioning, alarms or heating. The managing of the scenes must not be this complicated though, a simple control board with different switches for different scenes is often enough to fulfil the goal of efficient yet comfortable lighting.

The lighting scenes can indeed take form of a scene akin to the one in theatre. Leisure time can enjoy different lighting set-up than working, all in the same area. The lighting can even be remotely controlled, whether by a dedicated remote control or via a PC, tablet or even iPhone and iPad



Saving of power consumption by used control system (%)

	manual control	automatic control															
type of control	-	presence sensor			daylight sensor			combined									
degree		🚶	🚶🚶	🚶🚶🚶	✳	✳✳	✳✳✳	🚶 ✳	🚶 ✳✳	🚶 ✳✳✳	🚶🚶 ✳	🚶🚶 ✳✳	🚶🚶 ✳✳✳	🚶🚶🚶 ✳	🚶🚶🚶 ✳✳	🚶🚶🚶 ✳✳✳	
process of control	⎍	⎍			∿			⎍									
office	0	20	10	0	34	52	60	47	62	68	41	57	64	34	52	60	
conference room	0	40	35	30	32	50	58	59	70	75	56	67	72	53	65	70	
corridor	0	50	30	0	34	52	60	67	76	80	54	66	72	34	52	60	
class room	0	40	20	15	33	51	59	60	70	75	46	60	67	43	58	65	
retail	0	10	5	0	31	48	56	38	53	60	35	51	58	31	48	56	
industry	0	10	5	0	31	48	56	38	53	60	35	51	58	31	48	56	
store	0	30	20	10	19	29	34	43	50	54	35	43	47	27	36	40	

Annotation:

🚶	occasional movement of persons	✳	low daylight penetration
🚶🚶	normal movement of persons	✳✳	medium daylight penetration
🚶🚶🚶	frequented movement of persons	✳✳✳	high daylight penetration

Esprit

Esprit

Overall impression of the luminaire

Luminaire appearance in the room

Detailed solution, surface finish

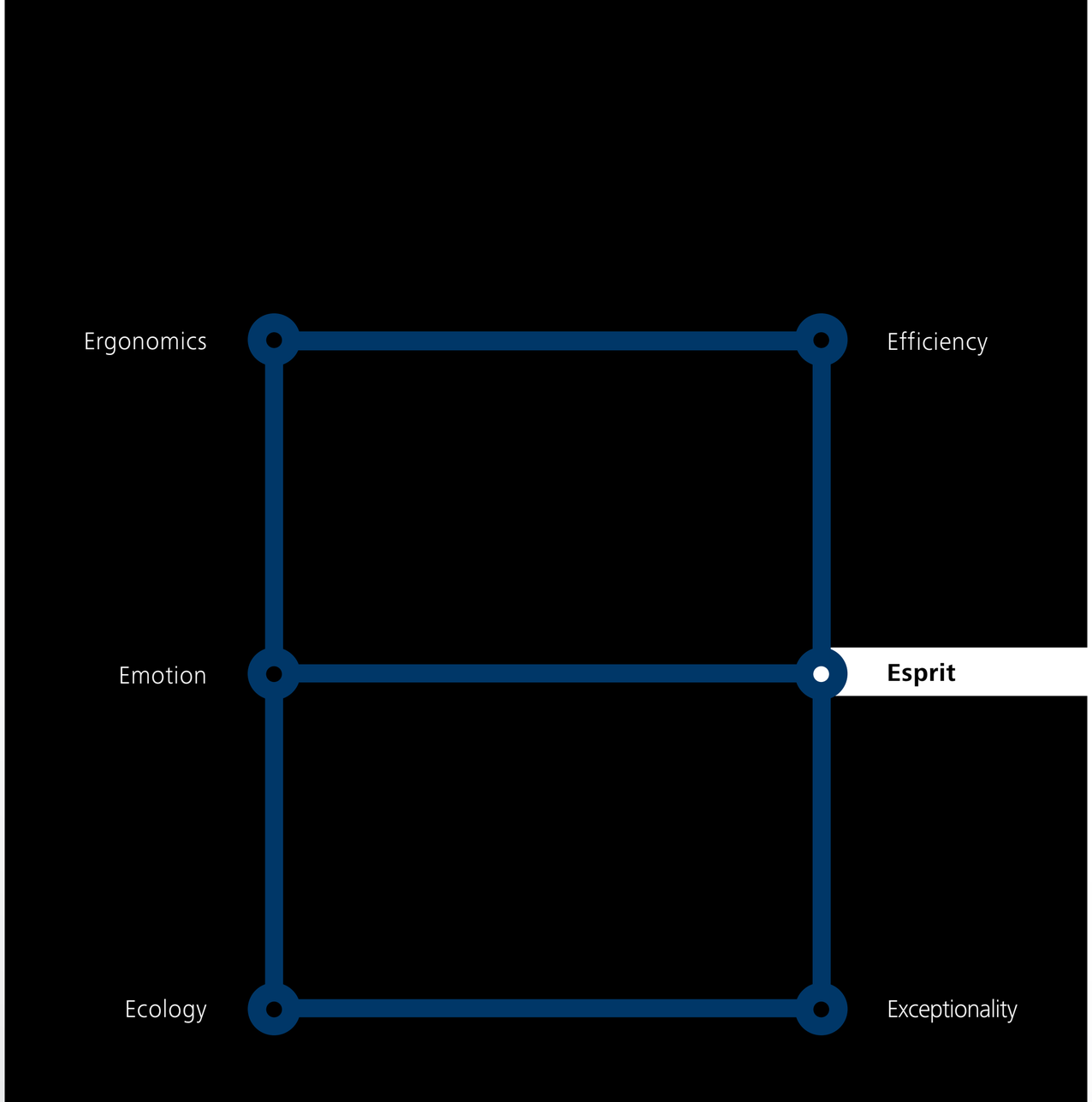
Materials of construction parts

Functional elements

Realize that look matters and enjoy the different shapes and moods the modern design of the luminaires provides.

The shape of an object with an excellent aesthetic value becomes an important accessory of the interior shaping in architect's vision.

The key Is 6 E's



And the impeccable soul behind the beautiful visage makes the perfect synergy. This combination gives the esprit to the non-living object.

The look matters. The beauty is to be enjoyed and cherished and not considered secondary to technical specifications. We all love perfect things. And the impeccable soul behind the beautiful visage makes the perfect synergy. This combination gives the esprit to the non-living object.

That is exactly what the state of the art design does to an ordinary luminaire. The current state-of-the-art design offers both minimalistic simple shapes and original, blazing yet functional ones. The choice depends only on the client's taste, the modern materials and technologies can satiate almost any desire, from a conservative to a modern one.

Although there are no quantifiable criteria to put the value of design in lighting quality standard, there are a few simple rules to respect in the light fixture creation process. Read on and learn how to affiliate the esprit of the luminaire with the LQS.

Overall impression of the luminaire

It is difficult to quantify the impression of the luminaire, yet it obviously affects the feel a given room or space has. A minimalistic one does not detract the attention from the room, yet does not diminish the atmosphere a space has either. Very roughly one can speak about Scandinavian school of design in this case – simple and with emphasis on function. On the other end we can see Italian design school, where elegance is also a significant part of the equation. This type of luminaire attracts the attention of the visitor, yet does so in a way that corresponds with the overall atmosphere of the space.

In OMS we try to design luminaires that are unique while keeping their design simple. The number one quality we are striving for is functionality though – it must remain unrestricted by the design but rather supported. Most usually, the design simply stems from the function – if the functionality requires for example cooling of the LED array, the design has to provide it in an unobtrusive, minimalistic or aesthetically pleasing manner.

"Although our luminaires are inspired by history and nature, they are striving to look into the future of lighting – we are constantly working with and researching the newest materials and technologies to achieve our goals. The aim is to set the future trends, not just follow them," explains the first OMS in-house designer Ján Štofko.

The overall impression of the luminaire consists of several factors: the materials used the positioning of the luminaire or a set of luminaires in the room, the shape and colour. The factors have to work in harmony both among them and with the room they are used in – an Italian design masterpiece might look odd in an industrial area and fluorescent aluminium lighting might feel out of place or uncomfortable in living space.

The designer is there to think through the planned application of the luminaire. For instance, in OMS we have several distinct lines of luminaires. The most basic Unolux provides subdued, functional design for a good price. The top line, Elite, is design to "sweep clients of their feet," as Ján Štofko puts it.

Designer also uses his technical prowess and artistic skills to overcome misconceptions. For example, LED light is widely considered as too harsh, technical and unfit for living spaces, yet the pace of technological development in the development clearly dismisses this myth. Indeed, providing a feel of sunshine in both his warmth and fullness is one of the main goals of the luminaire's esprit. It may be achieved by a plethora of factors and their combinations, but they always have to work in unison with the space they are applied to.

Designer uses his technical prowess and artistic skills to overcome misconceptions.

"We are constantly working with and researching the newest materials and technologies to achieve our goals. The aim is to set the future trends, not just follow them," explains the first OMS in-house designer Ján Štofko

Luminaire appearance in the room

The space and the luminaire have to work together, to connect and to fulfill the chosen purpose. If necessary, the luminaire has to supplant or enhance the sunlight coming from windows and other sources. During the night, its role is to illuminate the space to provide comfortable working conditions, relaxing atmosphere or even emergency guidance in spaces which are not used during the nighttime. All of these situations call for different approaches in design.

The luminaire first has to fit the idea the interior designer has for the space. It may not only provide the necessary light sources to create a well-lighted space. It can also have the role of accentuating certain focal points of the room. And of course, luminaire itself can be such focus of attention, if it is well designed and positioned.

The attention should never be the main reason for using a certain luminaire, though. Adequate lighting is always more important. If the lighting fits with the overall shapes and patterns of the room design, it becomes less ostentatious, letting people focus on the room itself. A contrasting light source, whether by shape, size, material or colour, can attract attention and become an object in itself.

Many iconic light sources fit this description perfectly. The finish of the luminaire should correspond with the space it illuminates as well. Glossy finish provides further reflections from both daylight and artificial light sources, something which should be kept in mind by the designer. Matt finish helps the conservatively-shaped luminaire to blend in well with the surrounding if that is the intention for a given room. Whether conservative or extravagant, the manufacturer should always provide a choice for a wide array of design decisions. The interior designer should always bear in mind the impression he wants to convey.

The attention should never be the main reason for using a certain luminaire. Adequate lighting is always more important.

Clearence – brand new LED luminaire by OMS

Detailed solutions, surface finish

The design decisions affect each and every component of the luminaire. The details are as important as the first impression the luminaire imparts. The designer has to be both technically skilled and artistically inclined to be able to blend both aspects of the design together. A close cooperation and communication with technicians is necessary, and so is the contact with the research team that provides new ideas for the future. “The result must be teamwork rather than the compromise,” OMS Product Designer Ján Štofko OMS says.

Although a common person may not see it directly, details are an important part of the functioning of the luminaire. Industrial lighting solutions for example can incorporate light level sensors which allow to adjust for the changing lighting situation during the daytime. This solution optimizes both the lighting and the energy costs. The known fact is that LED arrays demand a control circuit board and ventilation or cooling. The design has to take these requirements into demand without sacrificing the vision it has for the luminaire as a whole.

The surface finish largely depends on the materials used. The designer has to understand the material and its properties in order to fully use its potential. The extruded aluminium gives only a few options of finishing. Whether glossy or matt, it largely remains metallic-looking, a welcome feature in both living and industrial spaces, especially those preferring minimalism and function.

The plastics on the other hand provide a variety of colours to choose from in many different finishes. They can be either glossy or matt, opaque or translucent, smooth, dented or otherwise shaped as the design and the purpose demands. All these finishes affect the properties of the luminaire differently – the diffused light from the translucent plastic can take on the colour of the material and add to the atmosphere of the room.

Opaque, clearly shaped luminaire on the other hand can provide directional light where necessary, such as lighting a work surface. Gloss or metallic finish accentuates the reflections from other sources and surfaces in the room.

Details are an important part of the functioning of the luminaire. Close cooperation and communication with technicians is necessary, and so is the contact with the research team that provides new ideas for the future. The result must be teamwork rather than the compromise.

Eye – the luminaire created in cooperation of OMS, Bartenbach LichtLabor and Giugiaro Architettura

Materials of construction parts

There is no best or worst material, the choice has to come from the planned application of a luminaire.

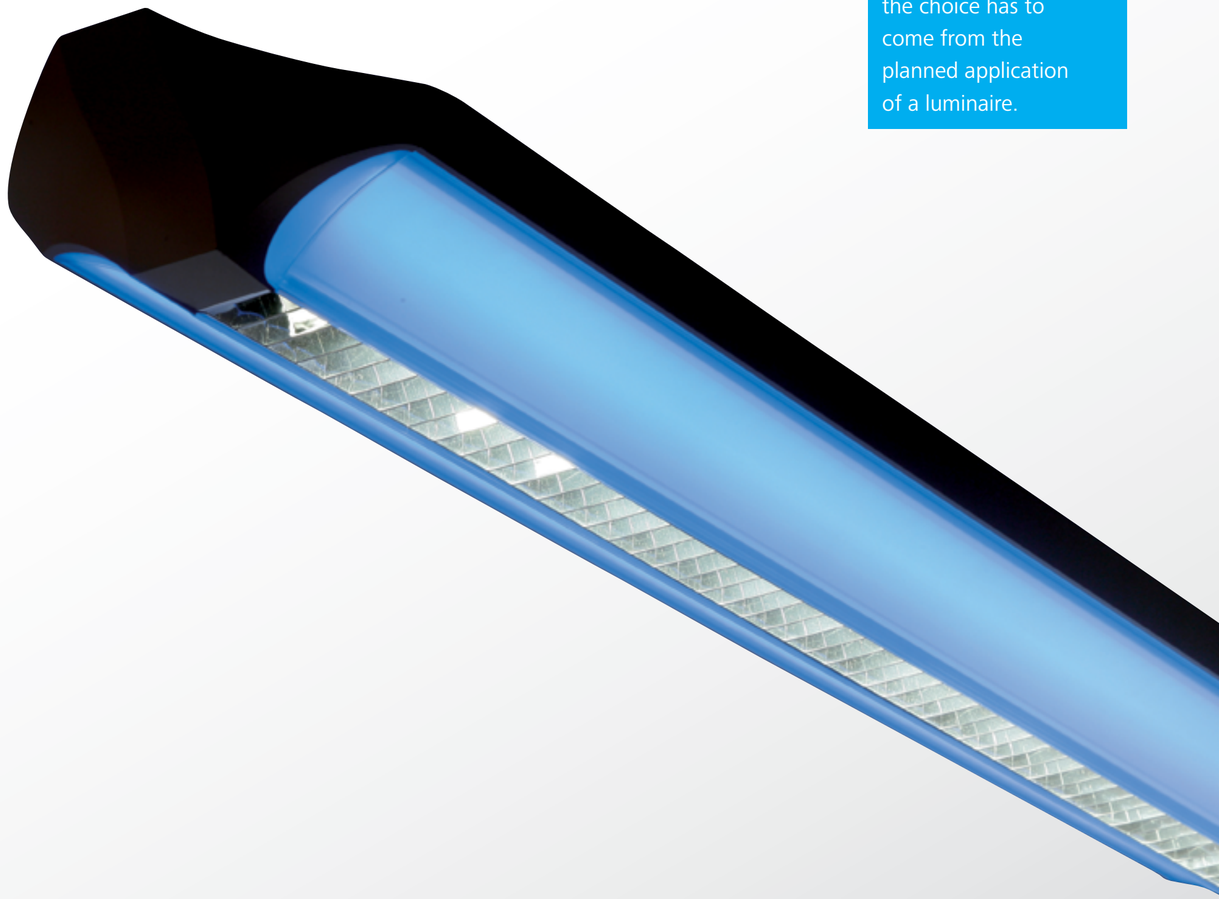
The most often used materials in the illumination universe – aluminium and plastic in combination with sheet steel – have their advantages and drawbacks. Extruded or die-cast aluminium with its industrial look fits both technical environment and minimalistic designed spaces while providing sturdy, long-lasting construction material that protects the luminaire from outside influences. Its available shapes are finite as well, it is difficult to curve and bend elegantly, for example. With proper experience and technologies eve this feat can be achieved, though.

Metals such as stainless steel, although demanded by minimalistic interior designers, are heavy and suffer from similar drawbacks as aluminium, namely the restricted possibilities for shaping. The sheet steel is often used as a backbone of a luminaire, it can be bent, welded or perforated to provide different effects and functions. Like aluminium, shaping steel comes at a price and demands experience and prowess.

The wide array of plastics, on the other hand, depends largely on the imagination of the designer to mould them into a desired shape. OMS is proficient at shaping polycarbonates and polyamides with plexiglass sheets used as a covering of a luminaire. Technical background for such moulding is necessary, as the moulds themselves require prowess and intimate knowledge and behaviour of the material used. With this savvy at hand, however, he can partake of the vast amount of colours, shapes and finishes that the plastics offer. Again, there is no best or worst material, the choice has to come from the planned usage of a luminaire.

Glass, whether blown or cut, also demands technical skill from the designer when used as a main material for a luminaire. He has to make sure that the brittle nature of the glass luminaire will fit the intended purpose rather than make it a drawback.
The insides are the most important part of the luminaire from the functional point of view – they contain the source of light itself.

Whether incandescent, fluorescent or LED, all have their specific demands for the materials used. Where LED has its necessary circuit board, which must fit the housing while fulfilling its role, incandescent and fluorescent light sources require either plastic or ceramic mount. The housing must be designed with heat dissipation in mind. For example the plastic near the light source must withstand the working temperature of the bulb or a LED array without melting or bending, even after prolonged use. A quality research and development team is there to ensure that such basic mistakes will not happen.



Functional elements

The innards of different luminaires, while using the same basic technology, are not created the same. The fluorescent lights for example can use higher-quality electronics to avoid high-frequency flicker, which can create an eye strain during prolonged use. Cheaper technologies do not take this into account. Yet eye strain in the workplace can lead to serious side-effects, from headaches to injuries. Just because of the wrong choice of element in the luminaire.

The most important part is of course the light source itself. Incandescent or fluorescent lights are ubiquitous already and LED lights are slowly getting recognized as well. In OMS we see them as an important future light source, able to save energy while providing light of the desired quality.

LEDs are not just a novelty unable to compete with other sources regarding the quality of light. The new technologies are improving the LEDs in a rapid pace. The top-line LED luminaires can provide theatrical lighting, alone or in combination with more traditional light sources. They are able to correctly render skin tones and red tones, the two significant factors of quality light source.

Light source is not the only functional element in the luminaire. The alternative can be movable parts inside the luminaire, which reposition light sources to create different effects or light temperatures which would suit different conditions as necessary. In OMS we are now developing a technology that would provide this flexibility without any internal moving parts, simply by arranging and switching different light sources inside the luminaire.

All these elements, which first and foremost there are to provide a demanded function, also have to be thoughtfully designed – the switches have to be accessible, the mounts have to fasten tightly and securely, but should be easy to reach and undo when they are to be adjusted. The light source housing should be protected from the environment yet relatively easy to open for maintenance purposes. In a perfect design, all these functions are taken for granted and self-explanatory with the client intuitively understanding them. In these cases, the design does not get into the way of the function, but aids and simplifies it.

All elements of every lighting device, which first and foremost are there to provide a demanded function, have to be thoughtfully designed.

Ray is a unique luminaire with combination of direct and indirect lighting designed by OMS in-house designer Ján Štofko.

Exceptionality

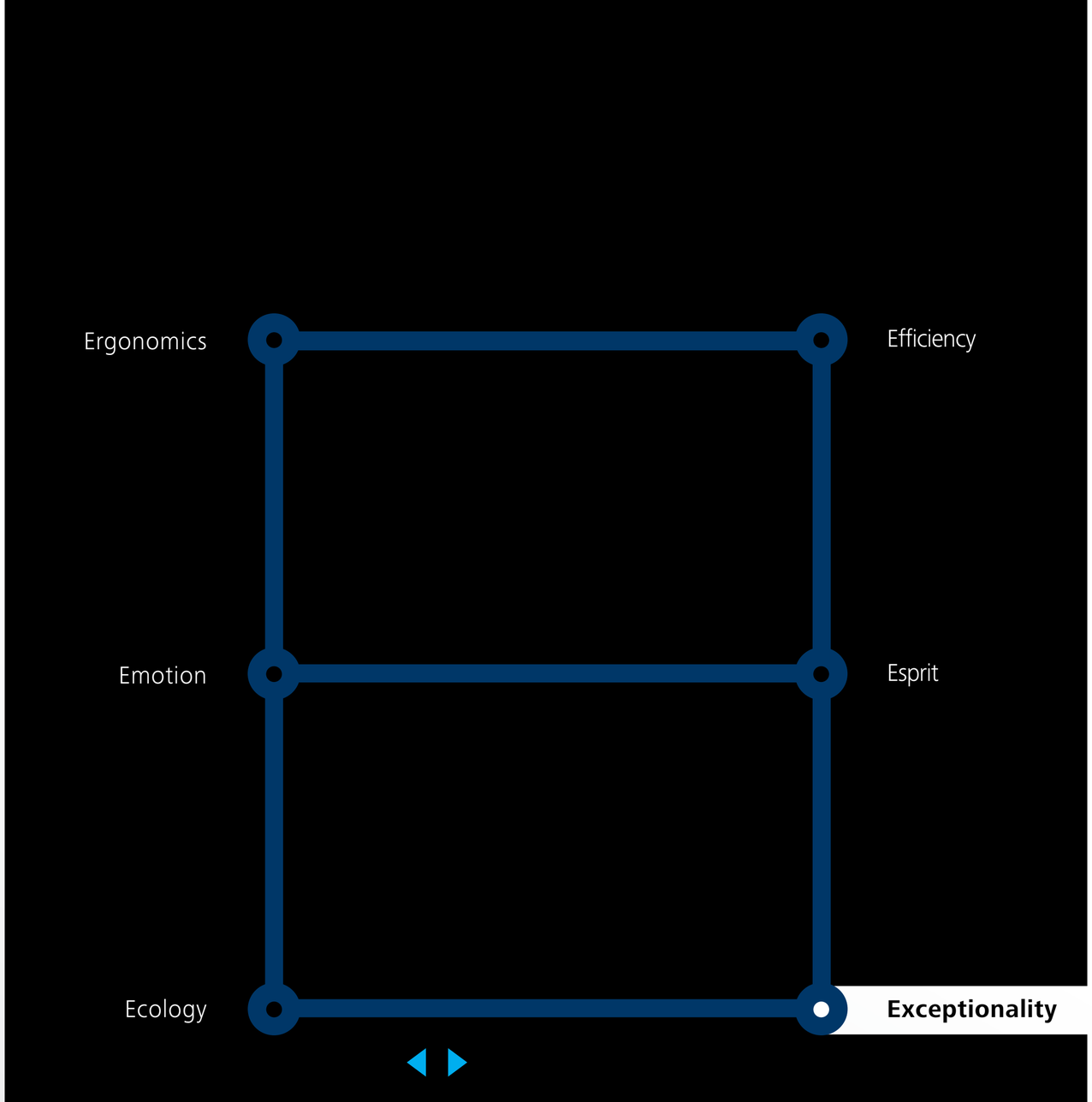
Exceptionality

Follow the right light

Recognize every customer as a unique individual.

Customized solution adds further value and comfort. Trustworthy partners prepared for unstable future of market and economic system changes are a necessity in the lighting world.

The key Is 6 E's



Every customer needs to be recognized as a unique individual. This is the kind of attitude making them feel exceptional. Trustworthy partners prepared for unstable future of market and economic system changes are a necessity; it is even more important to be both complex and exceptional.

No matter how many satisfied customers you have, if there is just one disgruntled, it can leave negative marks on your business forever. That is why each and every client is equally important. Happy customer is the best kind of promotion; his feeling can significantly increase your sales just by spreading the word to the others.

In OMS we recognize every customer as a unique individual. This is the kind of attitude making them feel exceptional. They know we are here for them – trying to satisfy their needs. For instance, we take attributes as flexibility and customization very seriously. Customized solution, if it's possible, adds further value and comfort. We are using the latest technologies to create high end lighting solutions and actively form the illumination market.

In world crises, trustworthy partners prepared for unstable future of market and economic system changes are a necessity not only in the lighting world. But with illumination sector on technological crossroads, there is even more important to be both complex and exceptional. That is why we added this as a part of LQS, although there are no quantifiable criteria here as well as in Esprit chapter.

However, once you absorb this chapter you will understand the prominence of Exceptionality perfectly.

Follow the right light

Exceptionality might be very vague term if not used cautiously. Everyone wants to feel special and unique at times. However, in business there is no margin for doubt. The mistakes are punished and imperfections are never forgotten. If you fail, the client might choose your competitor as a new partner and the company loses both money and goodwill.

This is why making a client feel exceptional is important. There are tools to measure customer satisfaction, but they do not tell the whole story. In the times of instability and uncertainty a partner with stability, vision, strength, flexibility and strong ethics stands out. Clients do not ask for just products anymore, they demand solutions. They are looking for trendsetters, not trend followers.

A wise customer is looking for an advice, a company offering full service, customized solution and courage to make the solution come true despite its complex nature. "We see solutions where others see obstacles. Where others see darkness we light the way," says Roman Krška, Commercial Director of OMS about company's philosophy in client approach.

This is the very core of Exceptionality in the unique LQS standard. In the lighting industry where strong competition is taking out the weak the company has to be in a forefront to succeed. "It is not about the big companies defeating the small ones. Rather the faster ones are defeating the slower ones, those with better quality defeating those being short of it. The more courageous ones prevail over those lacking courage. " Vladimír Levársky, CEO of OMS accentuates.

The lighting industry is first and foremost about complexity nowadays. The innovations are important, but do not suffice on their own. Modern technologies are important as well, but useless without a vision and human potential. Flexibility is the key element, but only when it makes sense – solutions which do not provide return on investments are worthless for both the producer and the customer. Following the trends is not enough, own ideas are what matters. This is why proprietary Research and Development Department and own design is necessary.

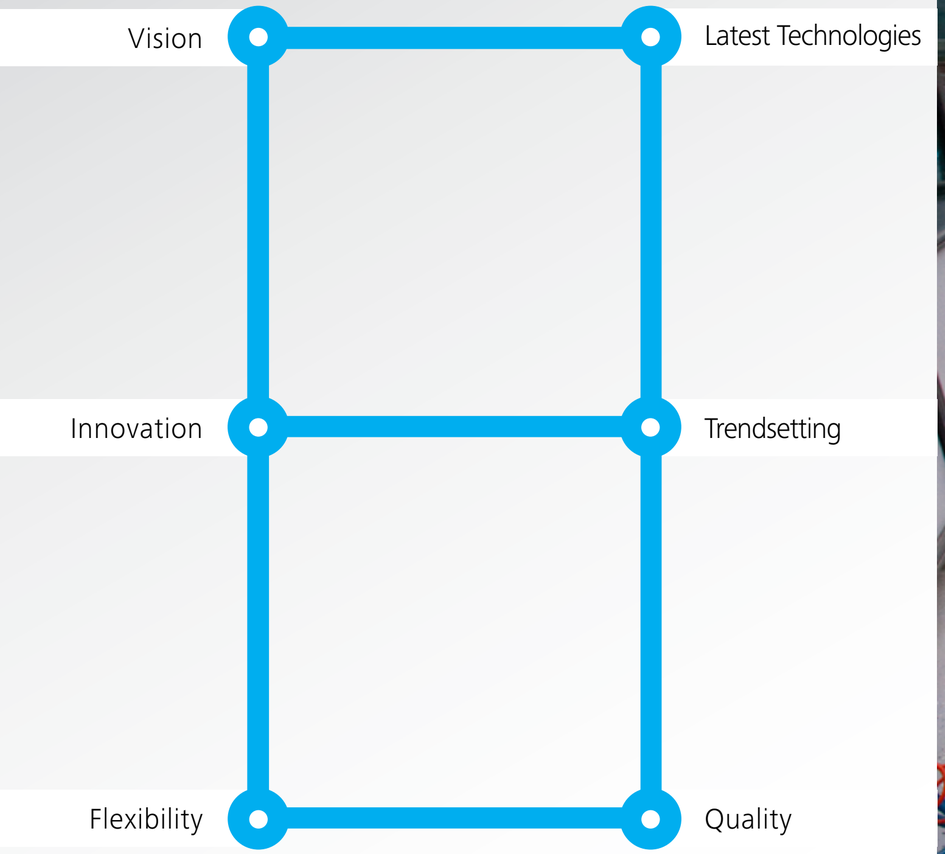
Complexity is one of the huge advantages of OMS. The whole creative process, including production and marketing of a product or even a whole complex solution can be done in-house, making the company competitive with the oldest and most respected global traditional producers. Strong research and development team provides ideas that are sold to customers through production and marketing departments. "Creative background and teamwork are the basis," Roman Krška says. Due to high quality and long term vision OMS is one of the fastest growing companies in the industry.

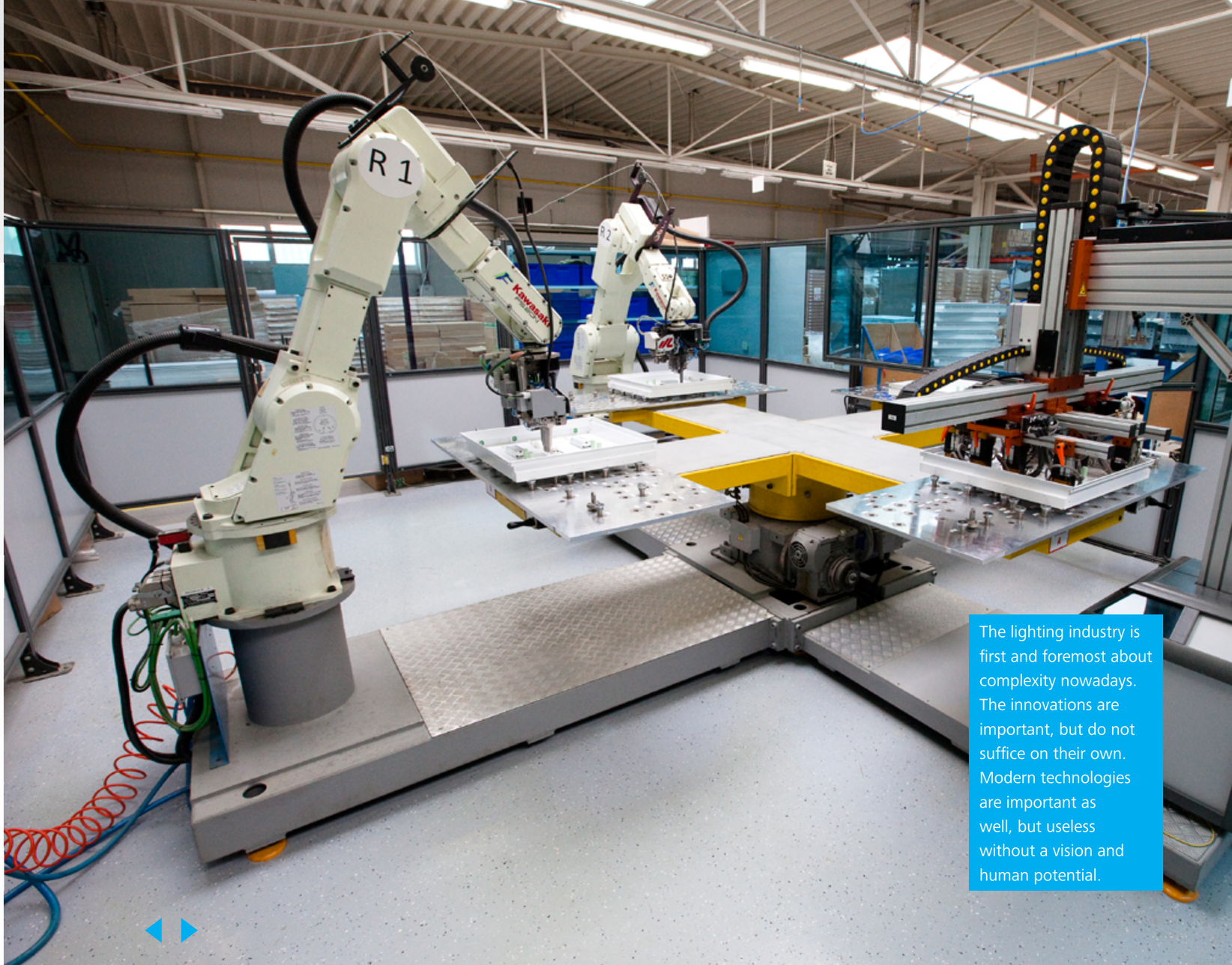
With our state of the art production facility in Dojč, Slovakia, we considerably contribute to the use and perception of artificial lighting for more than sixteen years in more than 120 countries worldwide. Our production programm covers all phases of the luminary creation cycle. Strong Research & Development gives input to Production and Sales to deliver high-class light fixtures and lighting solutions for our customers. Together with our thousand employees, we are thankful for the opportunities our customers provide us to prove our expertise and achieve our goals and visions adding to our company's value.

"We see solutions where others see obstacles. Where others see darkness we light the way," Roman Krška, Commercial Director of OMS

OMS

FOLLOW THE RIGHT LIGHT





The lighting industry is first and foremost about complexity nowadays. The innovations are important, but do not suffice on their own. Modern technologies are important as well, but useless without a vision and human potential.

LQS Composer

Office and communications

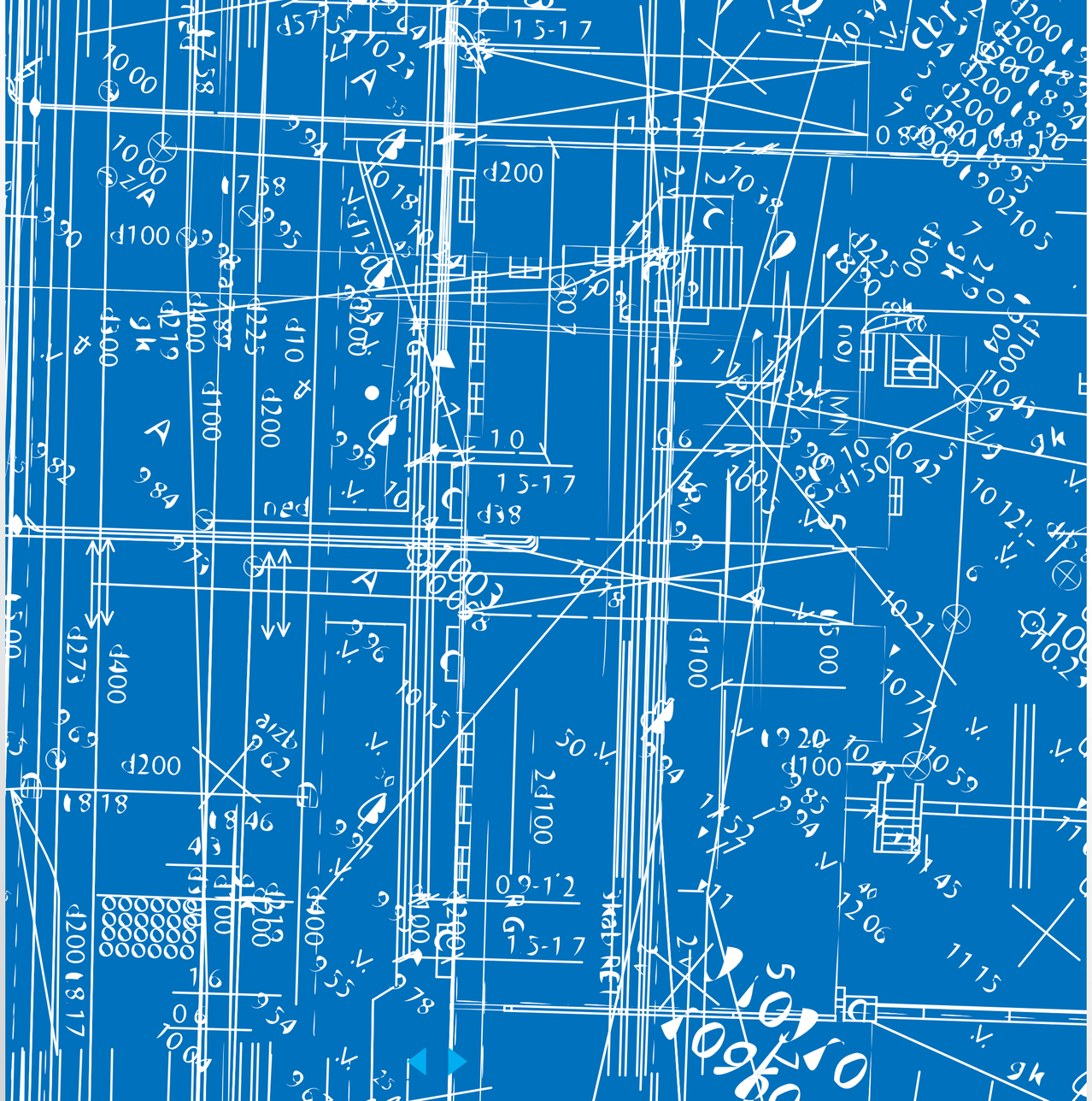
- Office
- Conference room
- Corridor

Education and science

Presentation and retail shop, shopping malls

Industry and engineering, outdoor workplaces

LQS Composer



Every luminaire and lighting solution is evaluated by over twenty quantitative criteria and as a result LQS Index is calculated. The higher LQS Index, the better the lighting solution.

LQS Composer is a unique computer tool that adds a new dimension to the LQS methodology. This is meant literally: this superstructure allows 3D modelling of luminaires and lighting solutions. The intuitive user interface and attractive visuals the LQS Composer will not be just a useful tool in your work arsenal. The time spent with LQS composer will be entertaining, too.

Every luminaire and lighting solution is evaluated by over twenty quantitative criteria. The criteria are ranked with LQS Value units. As a result LQS Index is calculated, defining the lighting quality. The higher the LQS Index, the better the lighting device or solution.

The demonstration shows six different environments with specific lighting solutions by OMS, providing the understanding of user value of LQS Composer. Just working with it will make understanding of LQS a second nature. Regardless of the type of interior environment that needs lighting, LQS is the best guide and help to pick out the most effective solution.

Office and communications

- Office
- Conference room
- Corridor

Office

There is a direct correlation between lighting quality and performance, motivation and overall well-being of the employees.

Multitude of people spends most of its workday in an office space. There is a direct correlation between lighting quality and performance, motivation and overall well-being of the employees. Several basic factors have to be taken into account when designing a lighting solution for office space. For example the artificial lighting takes up half of all energy costs in the office.

In this regard the utilization of lighting control systems has a great potential of cost savings. The controls are able to decrease the energy consumption considerably while increasing employee comfort.

The office spaces are illustrated by three solutions from OMS. Every one of them is of very high quality, but LQS allows for precise comparison. LQS index differs according to the lighting solution and the types of luminaires used. Higher index means higher quality.

A classic office lighting solution

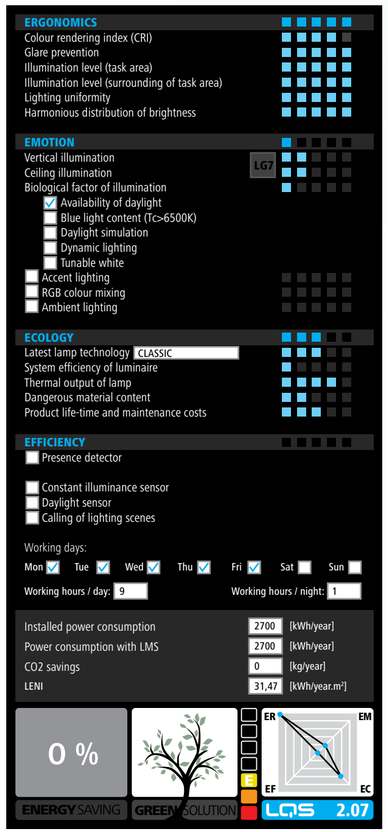
RELAX 600x600 4x14W

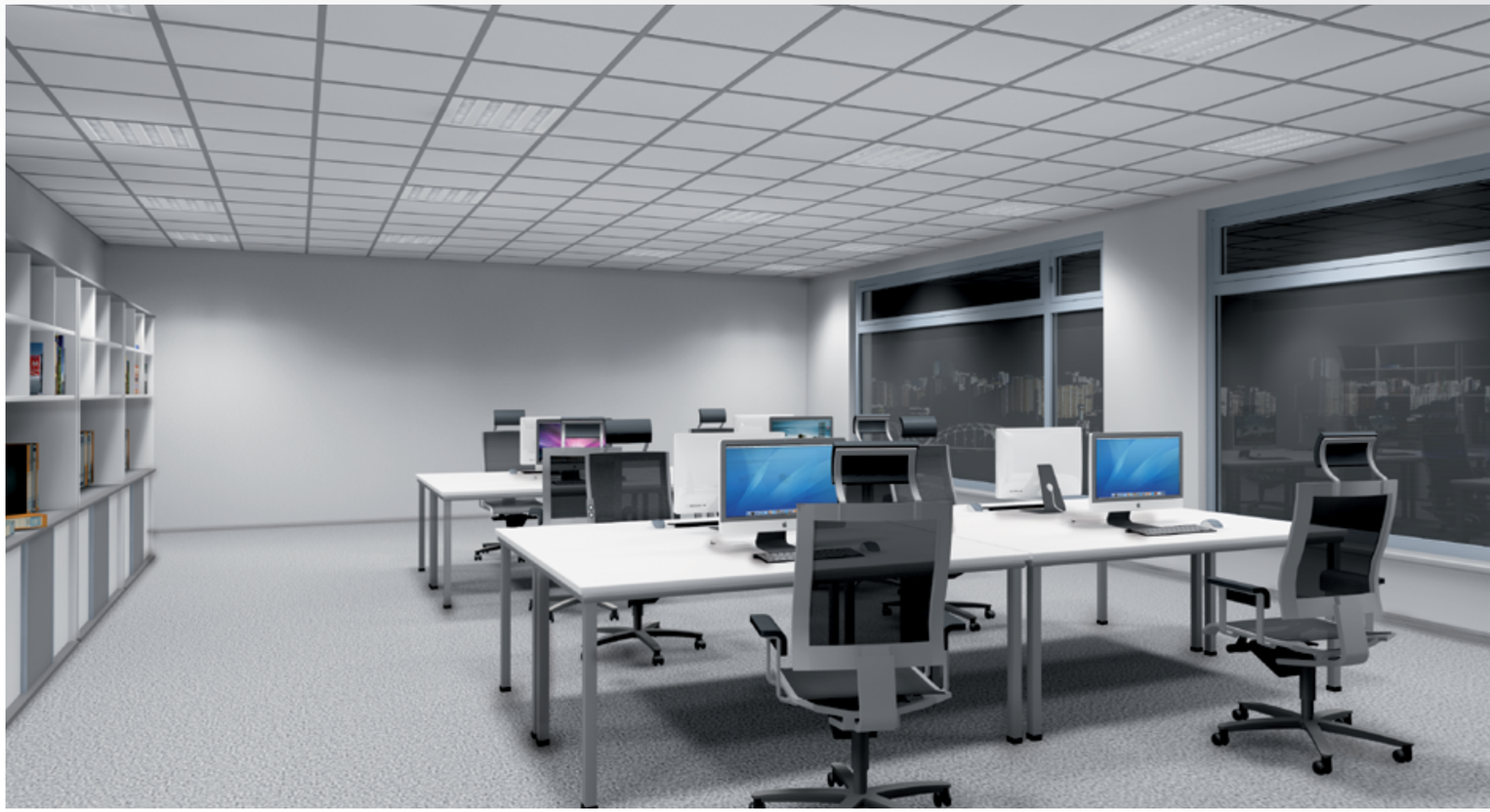
This is a standard when lighting office spaces. An important ergonomic element is parabolic louver, providing glare protection from the light source itself as well as protection from reflections on computer screens. RELAX luminaire has a very good horizontal illuminance and lighting uniformity.

This type of luminaire, while extremely popular, has several small drawbacks when compared to more modern solutions. One of them is non-uniform brightness on surfaces. It creates a dark ceiling and upper parts of walls.

Linear fluorescent lights used as a light source have only an average light output ratio and relatively high energy consumption. Due to these factors the luminaire has to withstand higher waste heat than when LED light sources are used.

Fluorescent lights also require more frequent maintenance and replacement and also contain mercury. This calls for a specific way to recycle used lights. The luminaire itself cannot be digitally controlled, as it cannot be connected to any sensors.





A modern office lighting solution I

VEGA 600x600
1x55W LED

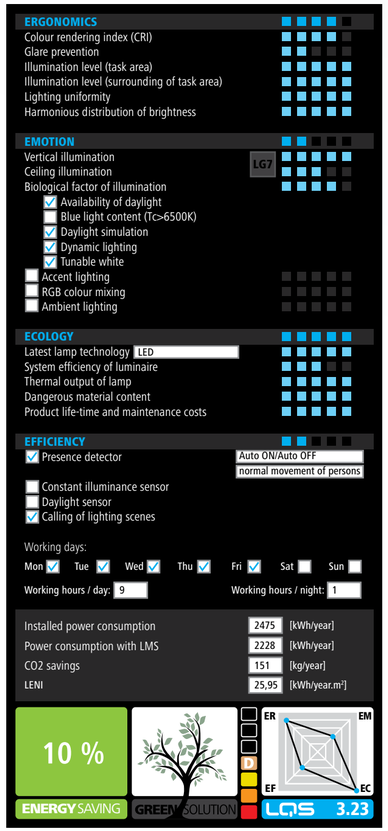
This luminaire provides new options for lighting solution in the office space. LED solution offers full replacement of the most often used fluorescent lights while allowing dynamic lighting to be used.

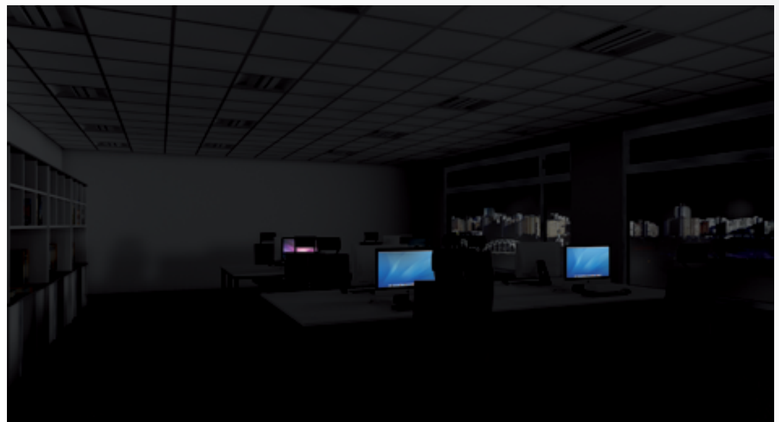
VEGA provides a high standard in the office space lighting. Ergonomically speaking it provides excellent uniformity of illumination and optimal brightness distribution provided by diffused lighting. The important factor is a high quality of illuminance at a task area and good rendering of objects in the environment without hard shadows.

Compared to its predecessors VEGA provides improved vertical and dynamic lighting. One of its main benefits is daylight simulation which allows changing and programming lighting intensity and colour temperature according to the time of the day.

Very high luminous efficacy and light output ratio of this luminaire is provided by LED light sources of the newest generation. Compared to fluorescent lights the heat dissipation is much lower and the LEDs do not contain mercury.

Efficient control is provided through a remote control, which allows the user to call any lighting scene desired. The touchscreen allows setting up lighting intensity and colour temperature.





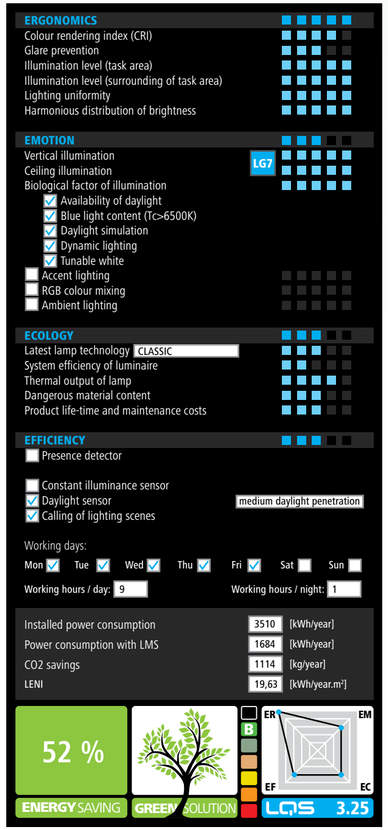
A modern office lighting solution II

RAY blue light content

A well-designed hanging luminaire with both direct and indirect lighting capabilities offers a concept of biologically effective lighting. It also provides excellent technical and lighting parameters. This is a high standard for office lighting solutions. Excellent distribution of luminance over the room surfaces, walls and ceilings lighted with soft diffuse lighting is provided by the combination of direct and indirect lighting. Excellent object rendering and no sharp shadows combine with the perfect lighting of a task area.

High quality of vertical and ceiling lighting fulfils the most taxing criteria of LG7. RAY does not obstruct windows and therefore allows direct access to daylight. Side diffusers hit the human eye in the correct angle, which in combination with cold fluorescent lamp provides the factor of biologically effective illumination.

The access to daylight helps in saving energy costs. The daylight sensors are then able to automatically dim or intensify the lighting intensity depending on the amount of daylight present in the room. Dimming, presence detectors and daylight sensors are all available for this luminaire. Attractive design can add to the interior design and makes it an attractive accessory.



Verdict
The winner is difficult to pick from among these quality solutions. The highest LQS index points to VEGA 600x600 Full LED (including VEGA Daylight). This luminaire has the lowest energy consumption. On the other hand, RAY blue light content offers biologically effective illumination and active control. Its attractive design makes it a popular choice among interior designers for office spaces.

Conference room

The conference rooms are also environments that represent a company to outsiders, clients or potential customers. The proper illumination should attract a random visitor and create a positive mood and image of the company.

Administrative workers as well as people in services spend a lot of their working time in conference rooms. It is used for different tasks – meetings, presentation, trainings, conference calls or negotiations with clients – which requires flexibility of the lighting solution used there.

The room should be able to accommodate a large number of people, yet be flexible enough to provide lighting for just two or three of them – dynamic lighting would save energy in this case. Access to daylight offers further opportunities for dynamic lighting.

The conference rooms are also environments that represent a company to outsiders, clients or potential customers. They can display awards received or even works of art, demanding further concentration on proper illumination. It should attract a random visitor and create a positive mood and image of the company. A multitude of purposes served by conference room has to be reflected in the final lighting solution.

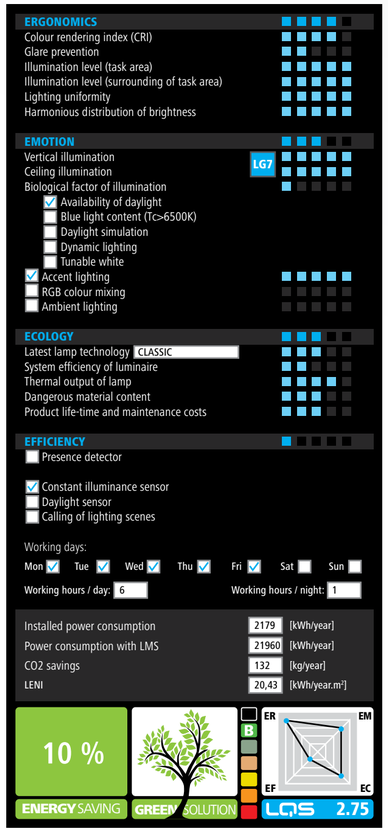
Classic lighting solution

EYE 4x28W,
AVANT OPAL 1x49W

This choice of luminary attracts with the design, which makes the conference room interesting. The lamps used provide standard colour rendering index. The lighting solution provides good vertical and ceiling illumination up to the recommendations of LG7 guidelines. The system incorporates accent lighting pointed at pictures hanging on the walls, providing further attractive objects in an otherwise simple white-walled room. The reflector of the luminaire can be adjusted, providing high-quality harmonious distribution of brightness.

The lamps used have the usual drawbacks: relatively short lifespan leading to high maintenance costs and they contain dangerous substances. Their energy requirements are much higher than in the case of LED lighting. The system can incorporate control mechanisms for dynamic lighting. This can be useful to adapt the room for different purposes: e.g. to dim the light during presentations or accent the whiteboard when training or meeting sessions take place.

With constant illuminance sensor and the system itself designed with sufficient overhead in mind the whole system can provide constant quality of lighting over its whole lifetime, never dropping below LG7 specifications. The new system would be working below maximum capacity with sensor controlling the gradual increase of luminous flux. Tthe light sources naturally lose it as they get older. Employing this sensor automatically means 10 percent energy savings.



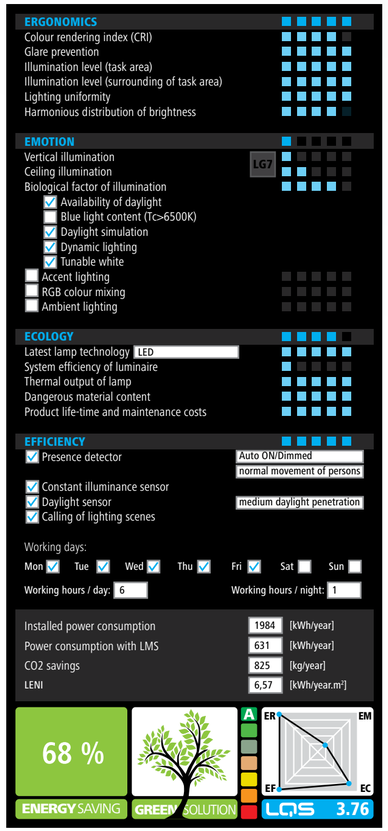
Modern lighting solution

BECRUX 1x28W LED

Unlike the previous solution with dominating design of luminaires this one calls for minimalistic, invisible lighting. The accent lighting used in this system provides extra illumination for the whiteboard, to be used whenever necessary. The LED lamps provide the possibility to tune white colour to different colour temperature. They also last much longer and dissipate less heat than flourescent lamps, driving down maintenance costs for the room.

LED solution again provides standard colour rendering. The task area is lit sufficiently with the optional accent feature for the whiteboard and additional accents pointed at the pictures on the wall. Tunable white feature can change colour temperature from 3000K to 5700K (warm to cool), changing the mood and properties of the room for different purposes as desired.

The whole system can take advantage of automatic lighting control that can employ presence detectors, constant illuminance sensors or daylight sensors. These can drive down costs significantly, especially if the sources of natural lights such as windows are present.



Verdict

Both solutions are very strong. The former offers attractive design of luminaires and very high comfort in the variety of uses of the conference room. Constant illumination sensor can maintain the desired quality of lighting for a long time while also providing energy savings. If cutting down costs is of the essence, the latter solution is definitely the one to choose: while the technology is more costly, the savings are significant. Also, the possibilities of lighting control are much more varied with LEDs than with fluorescent lamps, making it a good choice in the rooms that would utilize such controls. LQS rating prefers the latter solution due to higher ecology rating.

Corridor

Corridors sometimes have access to direct daylight, offering a possibility to use daylight sensors for keeping energy costs low.

While offices or classrooms are the environments where we spend most of our workdays, the corridors are more neglected when talking about proper illumination. They still have to provide proper object rendering and enough light to prevent high differences in brightness of room surfaces.

Corridors sometimes have access to direct daylight, offering a possibility to use daylight sensors for keeping energy costs low. Due to their intermittent use the corridors can be equipped with presence detectors, helping to further drive the costs down.

Navigating the corridor efficiently is also of importance. Accent and ambient lighting can be used to provide different cues – accent lighting can show from afar whether a given conference room is free or occupied, aiding the choice, reducing downtime and therefore improving work performance.

Classic lighting solution

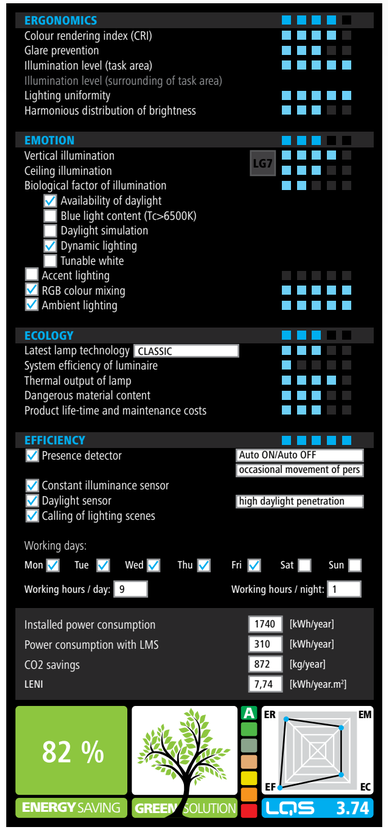
RELAX H LINE OPAL
1x35W, LINEAR
RGB 1x6W LED

This luminaire provides everything the standard calls for: correct colour rendering and high-quality lighting uniformity achieved by using linear lamp. The ambient and accent lighting can provide much more than just subtle visual cues – they can light up in corporate colours, change the atmosphere of the corridor dynamically depending on the time of day or nature of the event taking place.

The luminaire can take advantage of the eco lamps, the latest technology of the fluorescent lamps, saving energy and providing stable illumination with longer lifetime. It also contains less mercury, improving the ecology rating of the solution.

True cost-cutting effects take place when control systems are used: presence detectors can light up the corridor only when it is used and otherwise keep the illumination on a lower setting. Daylight sensor can be used in corridors with windows.

Constant illuminance sensor can keep the whole system at preset illuminance level during its whole lifetime, provided that certain overhead is factored in when designing the system. With combination of these controls as much as 80 percent of the energy can be saved.

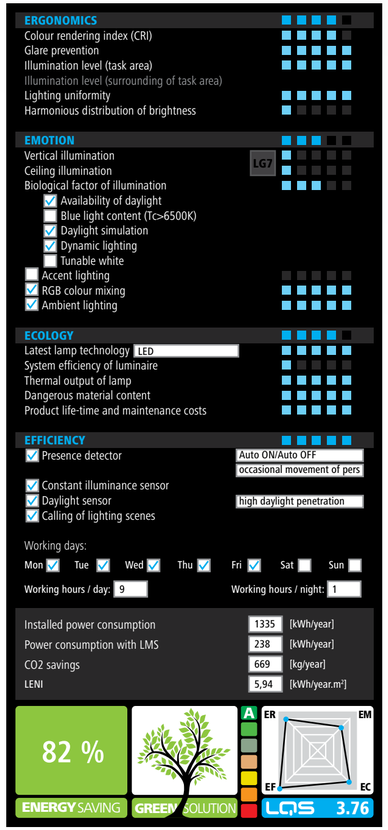


Modern lighting solution

BECRUX 1x28W, LINEAR RGB 1x6W LED

The strict standards for correct colour rendering are again fulfilled. The luminaire fully prevents glare and the lamp itself is basically invisible except when a person is directly down underneath it looking up. LEDs are by their nature prone to dynamic control. The change in colour temperature or mixing different accents or ambient lighting can improve mood in both those who use the corridors and the offices next to them.

Accents can also provide lighting for picture frames on the walls. With the appropriate mix of controls a simple corridor can create positive mood in e.g. visitors or clients who are coming to negotiations. Their mood will be adjusted even before they reach a proper conference room. From the ecological point of view this solution lowers maintenance costs due to extremely long lifespan of LED lights.



The presence detector and daylight sensor can again provide significant energy savings. The use of presence detector depends on how frequently a corridor is used: the less used it is, the higher the possible savings. The purpose of the detector is similar to that used in warehouse: when the room is empty, the energy use should be at minimum.

However, the lighting system should be able to light up immediately when a presence is detected so that the comfort level is not decreased when coming from a well-lit room. If the corridor is used very often the savings are less pronounced. Even in such cases daylight sensor can cut down energy usage significantly.

Verdict

Once again both solutions are of extremely high quality. The second option offers higher energy savings, however, especially in conjunction with automatic controls. These can be used by both solutions and with similar effects. If dynamic lighting is preferred then LED solution might be a better choice.

Education and science

The correct illumination of classrooms is therefore of paramount importance. This is not only to promote and help to better understand whatever is being taught, but also to minimize negative impacts of bad lighting solutions on the eyes of the children.

While the adults spend their time at work, the children, teens and young adults while away in the classrooms for much of their day. The correct illumination of classrooms is therefore of paramount importance.

This is not only to promote and help to better understand whatever is being taught, but also to minimize negative impacts of bad lighting solutions on the eyes of the children. Long-term eye strain might create chronic condition to suffer through for the rest of one's life.

The main task area in the classroom is the blackboard (and ever more frequently whiteboard) that needs to be illuminated sufficiently and uniformly. Glare is to be avoided at all costs especially with whiteboards which are prone to reflect light at glare-inducing angles.

The EN 12464-1 standards takes all these factors into account and sets very strict values to follow when designing a classroom lighting system.

Modern lighting solution I

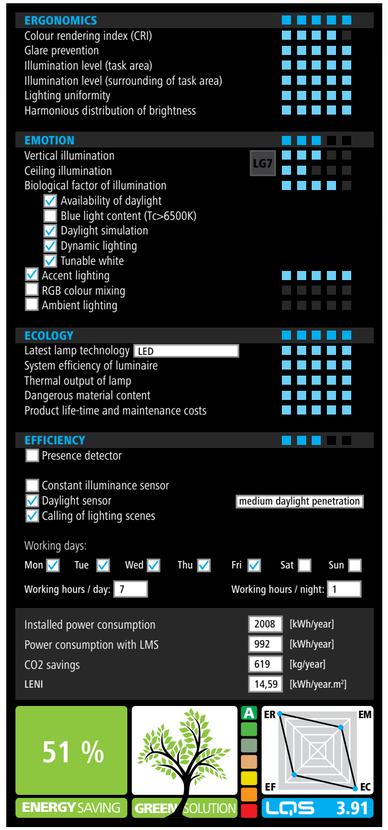
GACRUX PRISMA
1x52W LED,
RELAX ASYMMETRIC
1x47W LED

This solution renders the colours correctly and in a standard way, an important factor due to different uses of a single classroom. The whiteboard gets special lighting treatment with illumination of or over 500 lux via RELAX luminaire. This underlines the importance of whiteboard where huge amount of teaching process takes place.

The sufficient illumination is important for legibility of the whiteboard's content and it also automatically draws attention to it. The system also fulfils the strict standards for uniformity of illumination of a task area at or over 0.7.

The whole system can be further enhanced by other elements that improve biological well-being. The optional equipment includes daylight simulation control, dynamic lighting or tunable white to improve the mood and make the students more receptive, relaxed and less tired.

The lamps used provide energy savings and the system efficiency of the luminaire is very high, reaching 87 lumens per watt. The lighting can be also triggered by presence detector, offering further energy savings when the room is empty e.g. during a recess. If a daylight sensor is employed the system would fulfil the criteria of the highest energy class A.



Modern lighting solution II

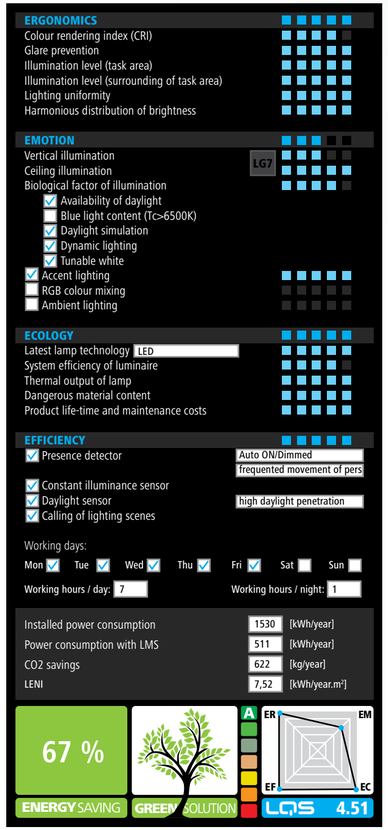
MODUL BOX MAX DIR/INDIR 1x73W LED, LINE RANGE ASYMMETRIC 1x47W LED

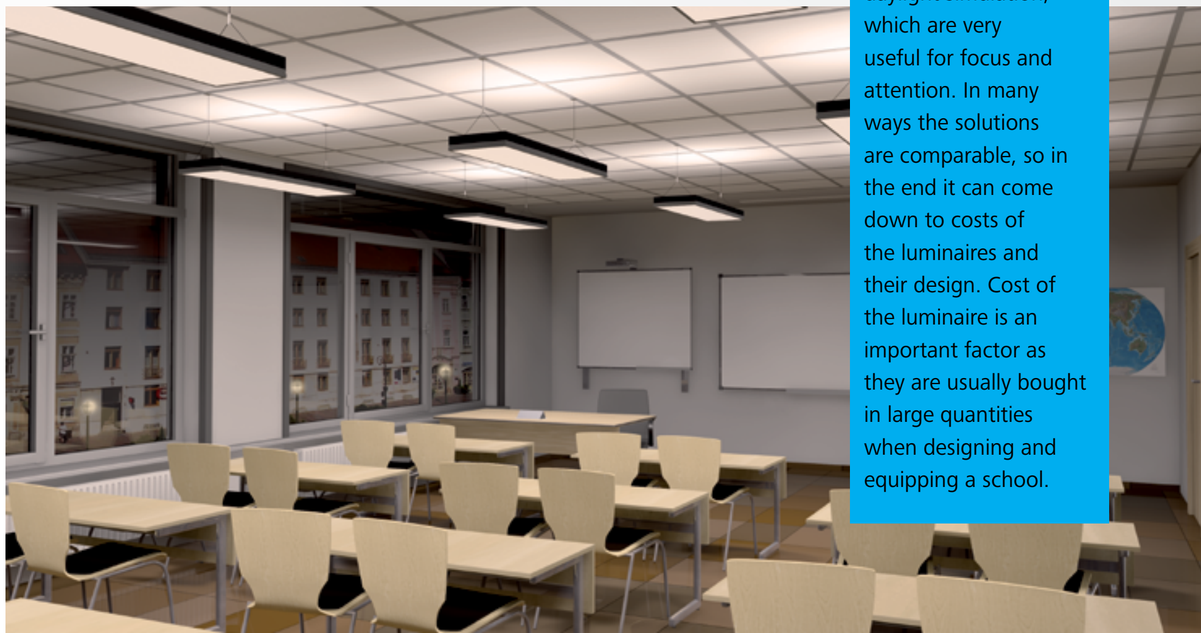
The ergonomic factors are the same as with previous solution. The whiteboard is illuminated correctly and with emphasis on uniformity of illumination. This solution comes equipped with elements that improve biological function. Similar to workspace, studying requires high level of focus in which new approaches to lighting can help in a big way.

Daylight simulation for example helps keeping circadian rhythms intact. Such an attitude not only helps focusing at school, it also does not inhibit correct sleeping patterns, preventing tiredness or attention deficit disorders.

LEDs used are natural savers of energy due to their lower energy consumption and lower radiant heat production, which means less work for air conditioning units. If daylight is present, the combination with daylight sensor can help save as much as 50 percent of lighting energy costs.

An important fact to mention is that LED lamps do not contain mercury or other harmful and poisonous substances and do not endanger the children.





Verdict
Both solutions offered are of extremely high quality. Both of them can be equipped with biologically enhancing technologies such as daylight simulation, which are very useful for focus and attention. In many ways the solutions are comparable, so in the end it can come down to costs of the luminaires and their design. Cost of the luminaire is an important factor as they are usually bought in large quantities when designing and equipping a school.

Presentation and retail shop, shopping malls

The correctly designed lighting solution is able to promote goods, motivate people to buy, set a positive mood, navigate shoppers through environment and create a positive atmosphere.

In retail spaces the correct lighting cannot provide just adequate illumination. The correctly designed lighting solution is able to promote goods, motivate people to buy, set a positive mood, navigate shoppers through environment and create a positive atmosphere.

Light has to render colours faithfully; otherwise the shoppers might be confused when they take goods such as clothing outside the store to the natural light. White colour can be tuned to present goods literally in the best possible light.

Even after hours when a shop is closed a correctly lit store can still attract potential customers. In short, a good lighting system can drive sales and revenues and can be an important decisive factor between success and failure of a store.

The retail environment is still concerned about costs, however. Modern technologies can help save significant amounts of energy and maintenance costs without compromising the desired lighting quality.

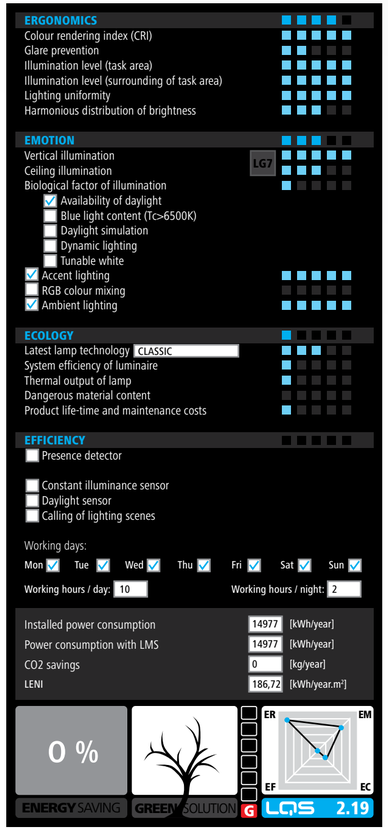
Classic lighting solution

ACCENT X5 1x70W, DOWNLIGHT VISION 190 ECO 2x26W, TUBUS CIRCULAR PRISMA 1x55W, RELAX ASYMMETRIC 1x28W, SIMPLE SWAT 1x35W

This is the usual combination used in retail spaces. It includes accent lighting to direct the attention to specific types of goods. They provide a good level of overall illumination, but at relatively high energy costs. Under this lighting setup the colours are rendered in a standard way. The workspace and presentation surfaces are sufficiently illuminated. Due to high brightness the rendering of objects suffers from sudden changes of light parts into dark ones.

The goods are usually presented along the walls, making correct vertical illumination important. Accent lighting, drawing attention to presentation surfaces, is the main part of the whole system. Due to their nature the light sources lack the possibility of RGB mixing.

Halide lamps used in this solution contain mercury and have a relatively short lifespan of about 12,000 hours, requiring frequent maintenance and therefore closing of the shop for maintenance purposes. Their main drawback in retail space is strong IR radiation.



Infrared light is basically radiant heat and most of the goods deteriorate over time under constant heat. This is true for textiles, foods and plastics of different kinds as well as other materials and types of goods.

The lamps cannot be dimmed or otherwise dynamically controlled; they take time to turn on or off to full intensity. The main customized lighting is the ambient lighting inset in the recessed ceiling which uses SIMPLE SWAT 1x35W luminaires. This solution has very high LENI ((Lighting Energy Numeric Indicator).

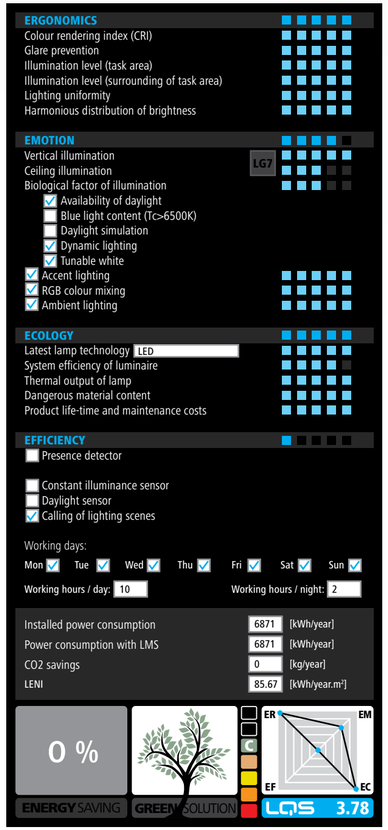
Modern lighting solution

AVIOR ADVANCED 1x31W LED, DOWNLIGHT VISION 190 RGB 1x40W LED, MODUL BOX SQUARE 1x52W LED, LINEAR RGB 1x6W LED, DOWNLIGHT SEELLER ADJUSTABLE 1x23W LED

The LED modules used in this solution provide colour rendering index of over 93. There are also spotlights for accent lighting: AVIOR ADVANCED luminaires have a special optical system. The faceted reflector decrease the risk of glare to a minimum and the whole system provides gradual decrease of brightness without any sudden drops. Such a solution is very comfortable both for the employees and for the shoppers themselves, as there are no visual distractions present.

The system allows the possibility to turn ambient lighting on and off. The vertical illumination is the most important with the goods presented on the walls.

The LED technology used allows RGB mixing of the ambient lighting, providing a desired atmosphere depending e.g. on weather or season. The mixing is fully programmable and can be controlled remotely. Very simple way of control helps the store owner in competition as the lighting can change rapidly, attracting new customers.



The LED lamps have a very long lifespan of over 50-thousand hours and do not react adversely to frequent switching on and off. Minute amounts of UV and IR radiation mean that the quality and colour of the goods do not deteriorate as was the case with metal halogenid lamps. Less infrared light also means that there is lower need for air conditioning, meaning further savings on energy costs.

The quality lighting design invites shoppers in and helps navigate the environment, thus increasing sales. During lunch hour when the shop is temporarily closed the ambient lighting can still feel inviting even though the rest is dimmed to save energy.

Verdict

New lighting solution based on LED lamps is able to pay for itself with energy savings and much longer lifetime, meaning less maintenance is required. Getting rid of the metal halogenid lamps is also beneficial for the quality of the goods being sold due to the amounts of IR radiation. Upfront costs can be high, but will soon return in both savings and increased revenues brought in by using more dynamic lighting that sets the correct mood and draws shoppers in. Lighting can be a decisive factor when several competing stores are found in the same shopping mall, for example.

Industry and engineering, outdoor workplaces

The warehouses are rarely occupied constantly; the tasks carried out there require enough lighting for object rendering.

Warehouses are environments where the user comfort is not as important as in the office spaces, an attitude that is also reflected in the EN 12464 standard. The warehouses are rarely occupied constantly; the tasks carried out there require enough lighting for object rendering.

But proper colour rendering is usually secondary. Glare prevention is important to mitigate possible injuries, but otherwise warehouse environment is not used for carrying out critical job tasks. However, there are still lighting solutions that are able to improve lighting conditions and ensure significant energy savings.

Ideally, the lighting would be dynamic, turning to full intensity only in the case of presence of employee inside. After the employee leaves, the lighting should shut down to emergency level, minimizing energy costs and prolonging the lifespan of light sources.

Classic lighting solution

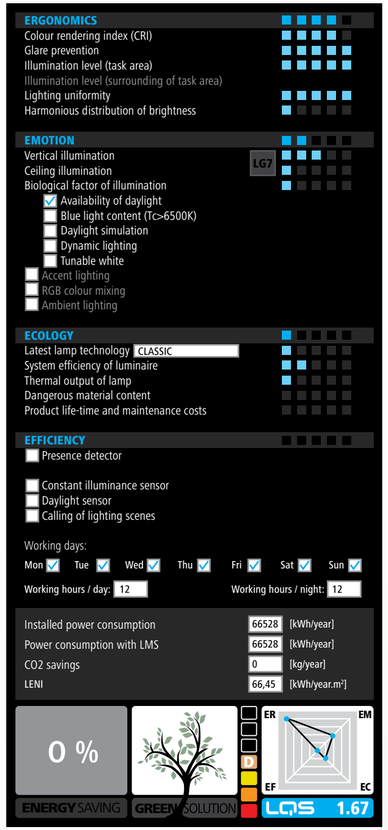
BELL 1x250W

This is a lower standard solution for warehouse spaces. The light source has high energy demands and is not illuminating the room surfaces uniformly. Its negative effects include light hotspots on the floors, uneven illumination of the stored goods. The efficacy of the luminaire is standard.

The metal halide lamp used requires maintenance and replacement. The maintenance itself is complicated due to the mounting height of the luminaire. The lamp contains dangerous substance – mercury, which means complicated recycling. The luminaire cannot be dynamically controlled or connected to sensors.

From ergonomical point of view this solution has many negatives – uneven illumination, different brightness of room surfaces depending on their height and proximity to the luminaire. Some surfaces are unnaturally bright while spaces far from the luminaire remain quite dark.

This is also a problem from the emotional point of view – such lighting solution does not evoke positive feelings. Ecology-wise this solution gets very low points as well – the light output ratio is only on a standard level and so is the efficacy. The maintenance is costly and complicated; the metal halide lamp has to be replaced quite frequently. Moreover, it does not allow using sensors, controls and other ways of lowering energy consumption – when turned off it has to cool down for 15 minutes before turning back on. The overall LQS Index of this solution is very low.



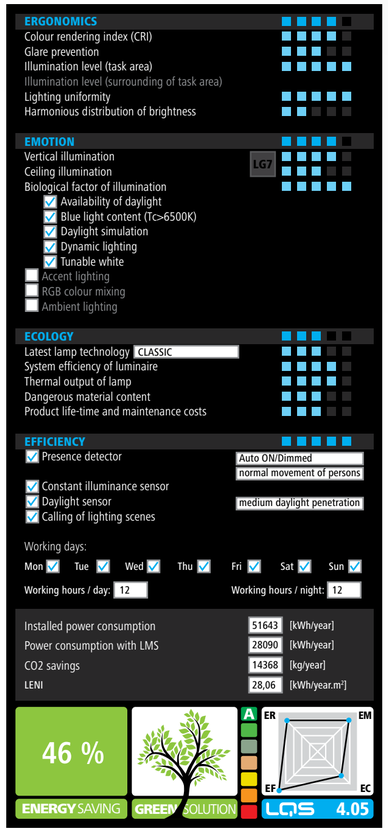
Modern lighting solution

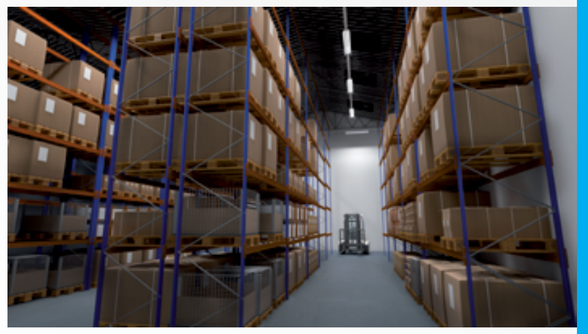
PRESTIGE 2x49W

This solution is ideal for all industrial purposes and represents a middle ground between old technologies and new LED lights which are expensive. Its LQS Index is much higher than in the former case: at lower energy costs the uniformity of surface illumination is much better, both on floor and on the goods stored.

The luminaire has high light output ratio. It also has a longer lifespan with extra long life light source used; lower maintenance cost and is more environment-friendly. It can also be hooked up to dynamic control and presence sensors. Ergonomically, the lighting is very uniform with good floor and wall illumination due to well-designed reflector used. Vertical lighting is much better than in previous case. Ceiling lighting is irrelevant in this case.

All the energy-saving options make this solution much more ecological, especially due to the combination with presence detectors. These turn the lights to 100 percent intensity when a person is detected in the environment. As soon as he leaves the intensity drops to just 10 percent, leading to massive energy savings. This also means smaller carbon footprint and the solution allows focusing on decreasing LENI (Light Energy Numeric Indicator) as defined by European standards. This means lowering the energy necessary to power lighting, given in kWh per square meter per year.





Verdict
While illumination of warehouses is not as critical as that of working environments, correct choice can both increase the quality of the lighting while also providing the cost savings. The second choice provides a much better lighting quality with improved ecological rating while also offering lower energy consumption. The automatic control elements take care of switching the light on and off, improving human well-being.

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