DOSSIER

LIGHT MANAGEMENT

Second edition, April 2015

ETAP

EXCELLENT LIGHTING, SAVING ENERGY

FOREWORD

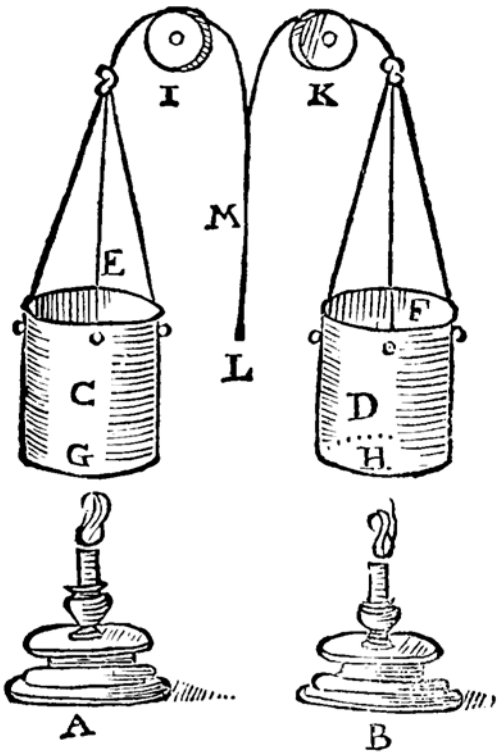
Since man discovered fire and was no longer dependent on daylight to illuminate the environment he has tried to control and adjust light to fit his needs. Lighting and putting out a flame can be considered as the earliest form of light management.

A more advanced way of light manipulation is dimming. In the 17th century Italian architect Nicola Sabbatini invented a mechanism to dim the light of burning candles by means of metal cylinders. Sabbatini's dimming installation was, just like the earliest forms of light management, intended for theatre applications.

The actual breakthrough for light management first came with the invention of electric light and later with the introduction of dimmers: initially magnetic dimmers and subsequently electronic ones, and later still communication protocols such as DMX and DALI.

It is impossible to imagine life without light management in modern professional lighting. Daylight-dependent control, motion detection, time control and other technologies cut energy costs and provide the desired illuminance at all times.

A tailored approach delivers the correct system design, in tune with the users' needs. With computer control and adapted software the possibilities are endless. ETAP has the experience and technical know-how to implement light management in every lighting project. We will show how we go about it in this report.



Nicola Sabbatini's dimmer (source: Dan Redler Stage Lighting Museum)

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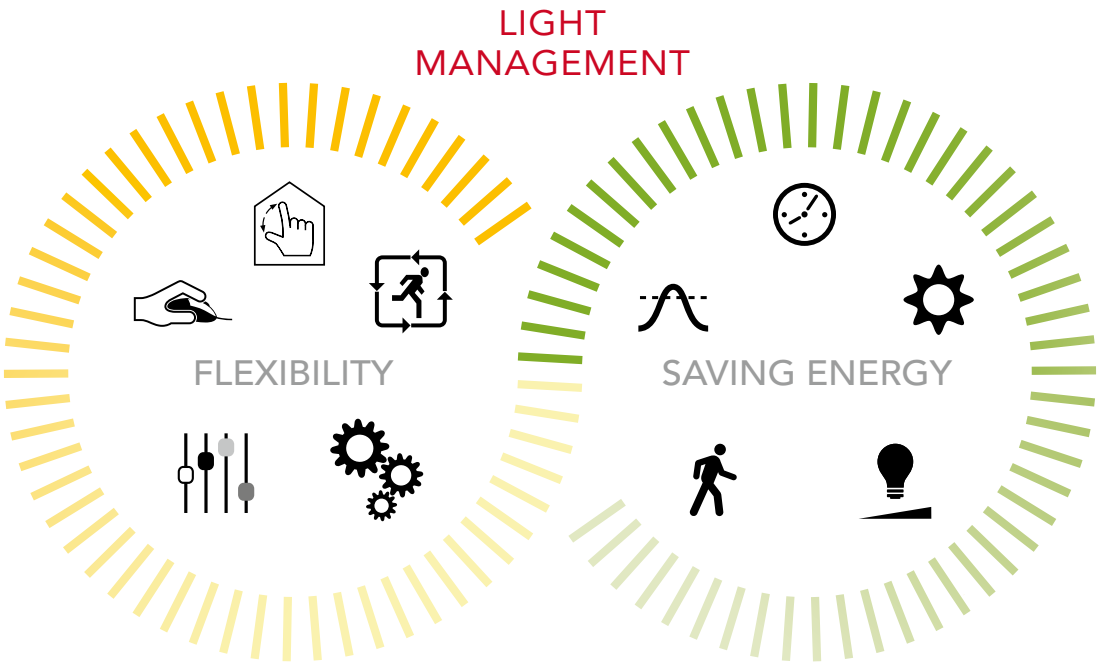
1. About light management



A good lighting control system provides an added value to the building and the lighting installation. Three principles are important in this: flexibility, energy savings and user-friendliness.

Flexibility: the fact that light control allows you to adjust the illuminance in a building without significant works is an unmistakable strength in a time of rapid technological and social changes.

Energy savings is often still the leading argument to apply light control. The savings potential is massive.

For maximum flexibility and energy savings, a lighting control system must be **simple in management and use**. A building administrator must be able to easily change the settings on his PC, via an internal network or the internet. A physical presence in the building to manage the lighting installation is therefore not necessary.
The software has a simple interface to adjust the lighting level or to launch programmed scenarios. It can be operated on a PC, tablet or smartphone.

When designing a lighting control system, ETAP applies ten strategies which we will explain in this file. We also demonstrate the huge range of possibilities that lighting control offers, from components for individual luminaires to computer controlled management systems.
Finally, we provide an action plan to install a lighting control system in accordance with the customer's needs, from planning and installation to management.

ETAP's ten strategies

FLEXIBILITY


Evolving with the building


Personal control


Scenario-setting


Integration with other technologies


Emergency lighting management

SAVING ENERGY


Smart time control


Daylight harvesting


Adjustment to the task


Occupancy detection


Limitation of peak load

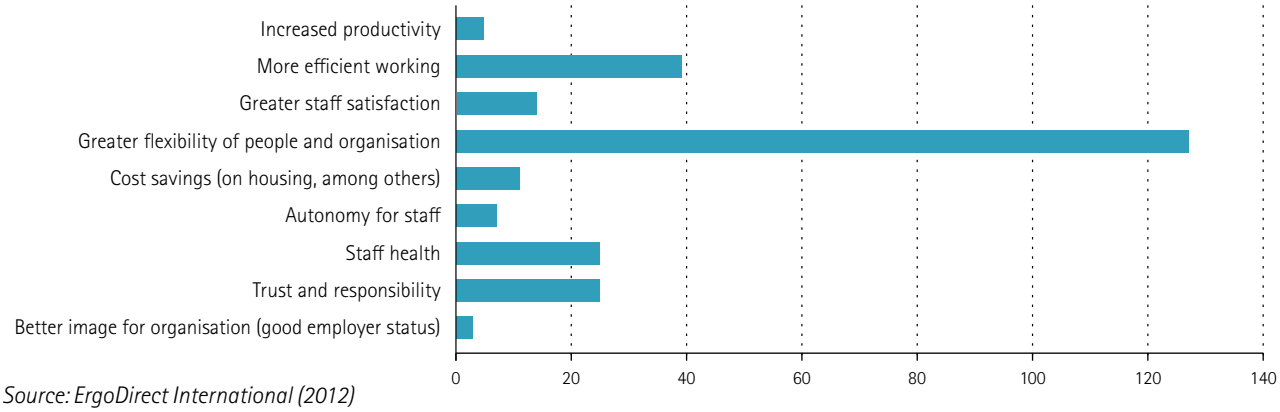
2. Flexibility

Technology changes exponentially, rather than linearly. The shelf life of new technologies (in nearly all industries) is getting increasingly shorter. This development runs parallel with – and is enhanced by – the increasing digitalisation of society. We work online, we shop online, we keep our social contacts online, etc.

THE NEW WAY OF WORKING

Superfast technological developments, combined with increasing computerisation, fundamentally change our way of working and therefore also where we work. An office building or production hall is no longer a static fact. A building's functions must be adjusted to new insights, new technologies, new production methods, new ways of working. The time of personalised office cubicles or

Which of the following aspects are most important to you in the 'new way of working'?



Source: ErgoDirect International (2012)

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individual workstations has passed. Organisations and companies are abandoning the concept of fixed workstations and provide a number of offices that can be used by various employees ('hotelling' or 'hot desking'). In this context, flexibility is the operative word. In a 2012 survey among 435 professionals, half of respondents provided 'greater flexibility of man and organisation' as the most important aspect of 'the new way of working' *(see graphic on previous page)*.

LIGHT WHERE AND WHEN IT IS NECESSARY

In this social and technological context lighting is also becoming more flexible. Constant illuminance in the entire office from 9 to 5 does not make sense and is even counterproductive. The right amount of light where and when necessary, is the central message. If the needs change in a space, illuminance must also be easily and quickly adjusted, without major works. The implementation of light management systems then becomes more of a necessity than a secondary consideration.

Flexibility is not only related to time of day. One space within an organisation or company can fulfil several functions depending on use. Just think of a room in which a meeting is held in the morning, presentations in the afternoon and in the evening a customer event is taking place. Since these various functions require different lighting, light management can be a godsend here. Through pre-programmed scenarios the right lighting can be configured for the right use (with a single press of a button).

INCREASED COMFORT

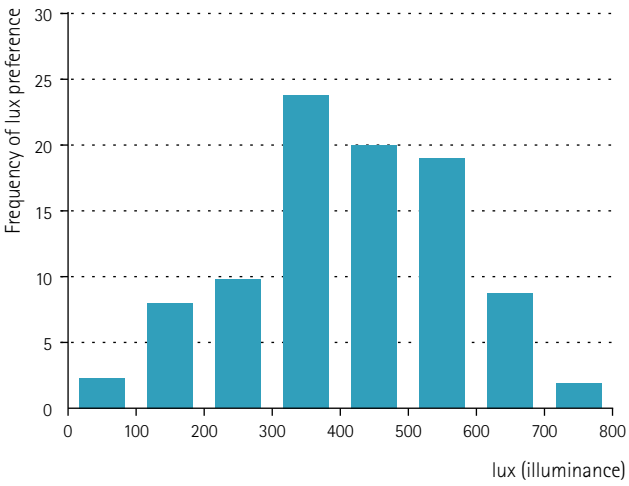
Flexibility also means personal control. With light management the individual employee can adjust the lighting level to their preference. Age is one of the decisive factors in this respect.

Age	Lighting needs for reading a book (in lux)
< 25	250
25-65	500
> 65	1000

Source: IES, The Lighting Handbook

Numerous studies show that variable illuminance during the day improves comfort and indirectly also staff productivity. The fear that most employees will opt for too high an illuminance is for that matter contradicted by practice. In a Canadian study, staff was able to express their preference about illuminance in their office. The majority opted for values between 350 and 550 lux, which is perfectly in line with European application standard EN 12464-1 *(see diagram)*.

Desired illuminance in the workplace



Source: National Research Council Canada (2009)

Lastly, light management fits into the increasing trend of 'building automation'. Light management can be integrated into broader building management systems and thus contribute to maximum flexibility in a building's operations.

2. Flexibility

ETAP applies five strategies with respect to flexibility. Together with the customer we determine what strategy is most suitable in order to achieve the desired flexibility in their project.

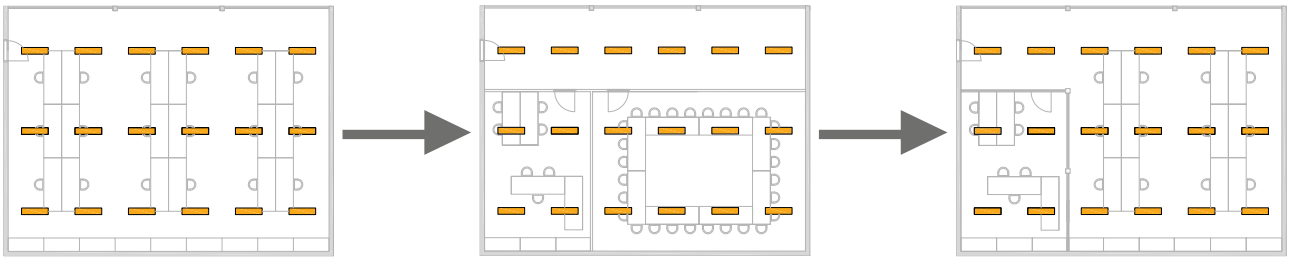
Evolving with the building

A building's or workplace's function is no static fact. With light management, lighting can also easily evolve with changing needs over time.

A building or part thereof can change purposes. Light management systems provide the flexibility to deal with these changes without the need to add or remove luminaires or to pull wires through dividing walls.

A simple way is to make the light dimmable throughout the entire building. Whenever a space is given a purpose that requires higher or lower illuminance, all it takes is to adjust the dimming level.

More sophisticated systems divide a building into zones where the lighting can be controlled via the computer.
Individually addressable luminaires offer the greatest flexibility. This allows you to set the lighting level of each luminaire individually.



A space can be laid out differently over time. Light management allows lighting to evolve without expensive adjustments.

Personal control

When users are given control over the lighting at their workplace, they can adjust it to suit their personal preferences.

Light management systems with personal control provide the employee with the option to adjust lighting, with push buttons, through a computer interface or by remote control.

Personal control over the lighting in the first place increases flexibility, but also the employee's sense of satisfaction. Those who have the option to adjust the illuminance to their preference, experience this as a plus point. Studies have shown that on average this results in a 10% energy saving *(source: Pike Research)*.

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Scenario-setting

Light management allows the definition of scenarios to quickly adjust the lighting to the various functions of the individual rooms.

Light management systems provide the flexibility to adjust the lighting to the functions of a space. For each of these functions you can define scenarios that determine the type of lighting and the lighting intensity. You can then activate these scenarios by a single button press.

Such scenarios can also be applied architecturally to create various moods in the building. This type of scenario-setting is common, for example, in auditoriums, reception halls, restaurants, hotel lobbies, etc. In outdoor lighting scenario-setting can also be applied for architectural or advertising purposes.

Integration with other technologies

Light management systems with interfaces to current lighting standards enhance flexibility and freedom of choice. In addition, they must be capable of being integrated into a building management system.

Light management systems must be 'future-proof', to allow them to evolve with technology. That is why good light management systems interface with standards used in the market, such as DALI. In this way, they can also work with components (sensors, detectors, etc.) from several manufacturers, which benefits the flexibility of the light management and can reduce the cost price. This 'openness' does not prevent a system from using its own standard for light management, in order to overcome drawbacks inherent to less efficient systems. An open system to ETAP means an optimal combination of own protocols and market standards.

The latter also applies to integration into a broader building management system. It must be possible to link light management to existing protocols for building management. Presence sensors not only manage the lighting, but can also, for example, control the heating, ventilation and air conditioning, activate an alarm function, etc. Integration into a broader building management system further increases both flexibility and potential energy savings of light management.

Excellum2, ETAP's light management system, can operate with all market standards. Thus it is able to communicate with other systems, such as air conditioning and heating.

2. Flexibility

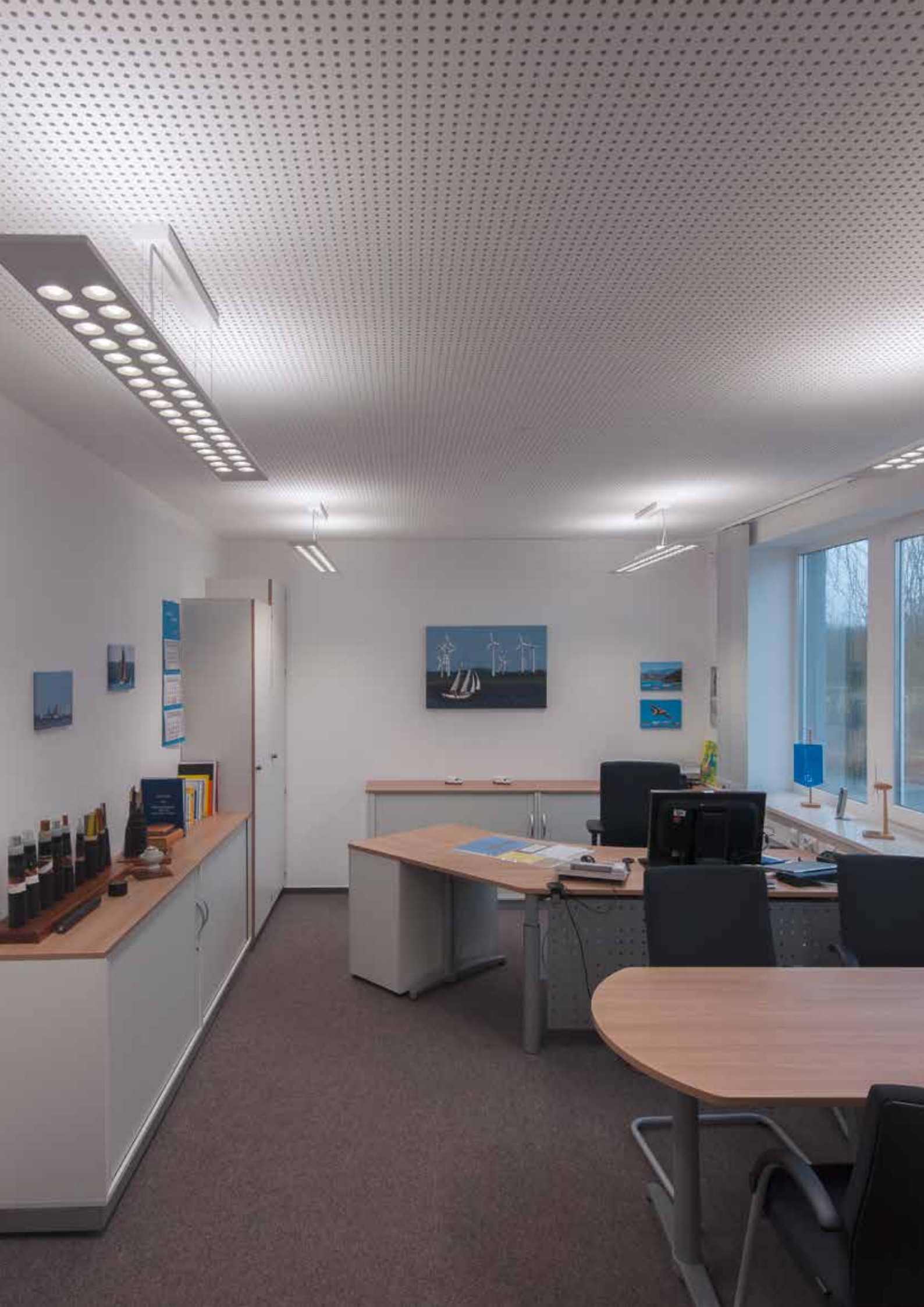
Emergency lighting management

Emergency lighting management can also be integrated in a lighting control system. This can save you a lot of time, particularly if it concerns an extensive installation.

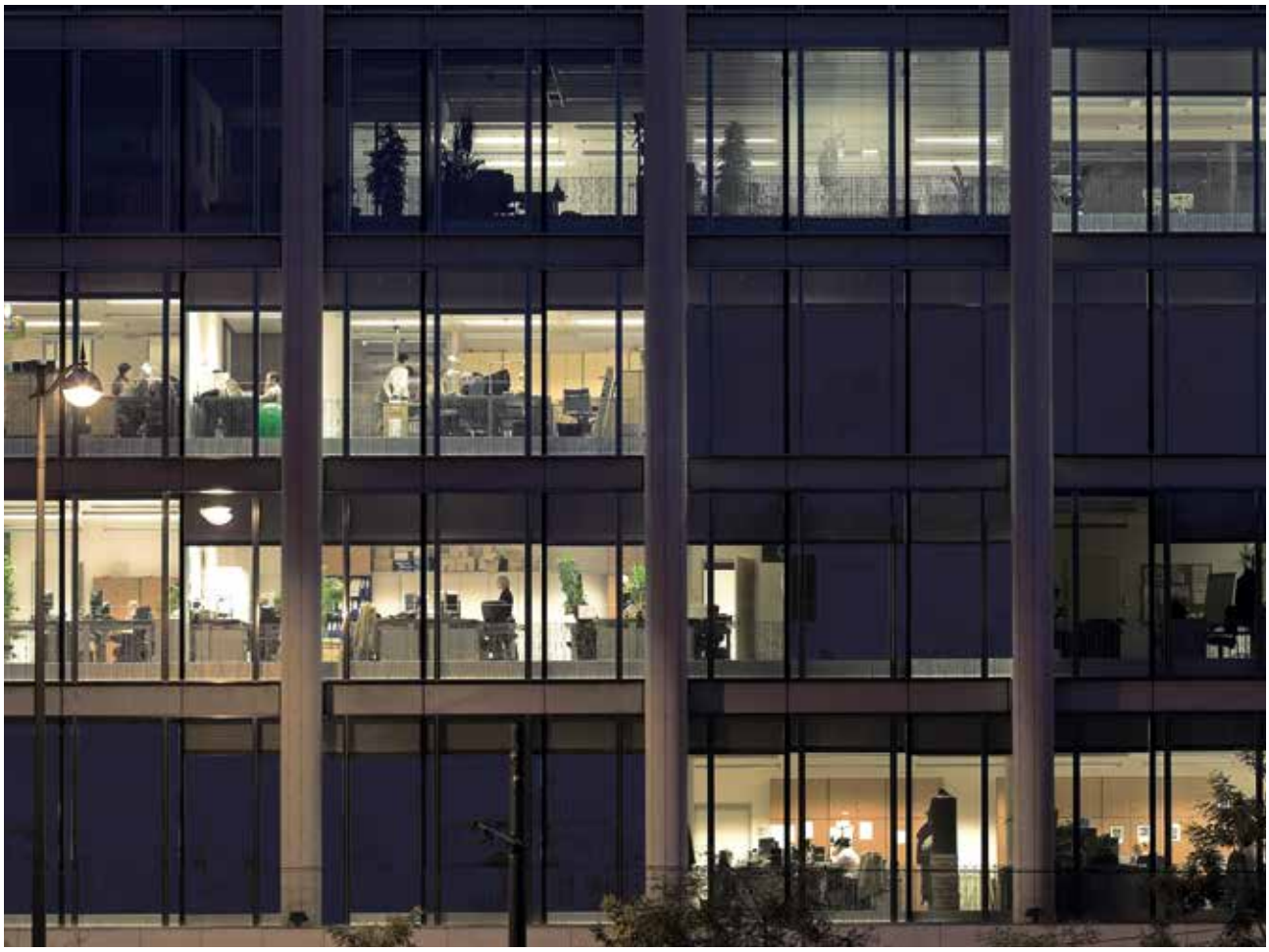
You always need to be able to rely on the emergency lighting. That is why correct monitoring is essential - and often also required by law. A lighting control system helps with this. The building administrator is able to check the status of the luminaires at all times. He does not have to be in the building for this: the software also gives a warning in case of a safety problem.
Active emergency lighting management is also possible with the lighting control system. This allows the (obligatory) function and duration tests to be planned and adapted.
And finally, the system also keeps a log of the tests. This is obligatory in accordance with European standard EN50172. But this log is also a handy tool to have the most complete and current information about the emergency lighting installation.

Correct monitoring of the emergency lighting in a building is essential. A management system can save a lot of time in this respect.

Schleswig-Holstein Netz AG offices in Nieubüll, Germany. Local light management with EasyDim.



3. Energy saving



In modern operational management energy-efficiency has become an obvious focus. This has to do with cost price, but also with increasing social awareness and more stringent regulations.

AWARENESS

Energy-savings has increasingly become a vital attitude. No one with common sense will dispute the impact of increasing energy use on climate. The most pessimistic studies forecast an increase in temperature up to 6.4 degrees with unchanged energy use. Limiting the increase in temperature to 2 degrees, which is considered to be the absolute limit, requires a 75% reduction in greenhouse gases.

REGULATIONS

More stringent regulations will also encourage energy-savings. The 2002/91/EC guideline of the European Union imposes minimum standards for the energy performance of new buildings and in major renovations. In addition, there are international standards such as EN15232, and the increasing importance of quality marks such as BREEAM and LEED, which measure a building's sustainability performance.

COST PRICE

A third important factor is the cost price. Whilst cost reduction in a global economy is playing an increasingly important role, energy prices are rising and therefore also electricity prices *(see diagram on the next page)*. It goes without saying that light management systems also cost money, but cost recovery, depending on the specific application, can be surprisingly short.

MAJOR SAVINGS POTENTIAL

It is unavoidable that the importance of energy-saving in general and saving on lighting in particular is on the increase. Worldwide some 17.5% of energy use goes to lighting. Depending on the type of building and/or the activity the share of lighting in a company's energy use can add up to more than 50%. The savings potential is therefore very high.

Heating and ventilation are for the most part adjusted through calendar control. Employees would be surprised if the temperature in their office would have to be adjusted manually every day. In lighting this is still more the rule than the exception. Yet sophisticated light management can save a lot of energy. According to the International Energy Agency a combination of motion detection and daylight -dependant control can result in a 50% saving. With

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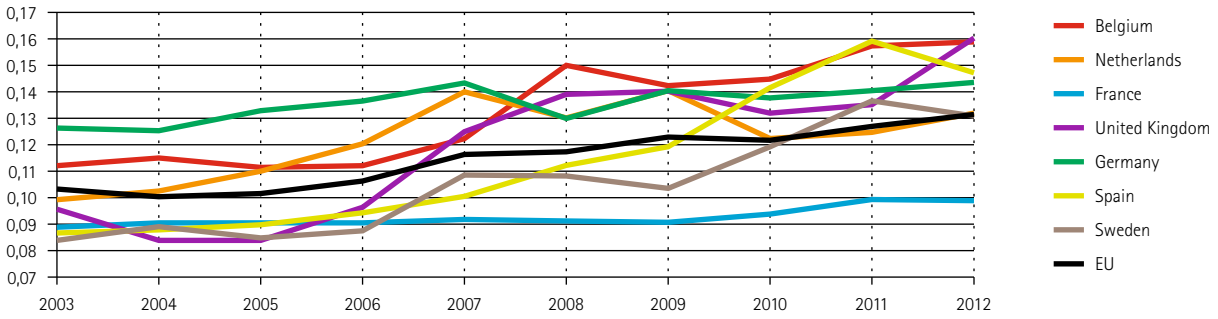
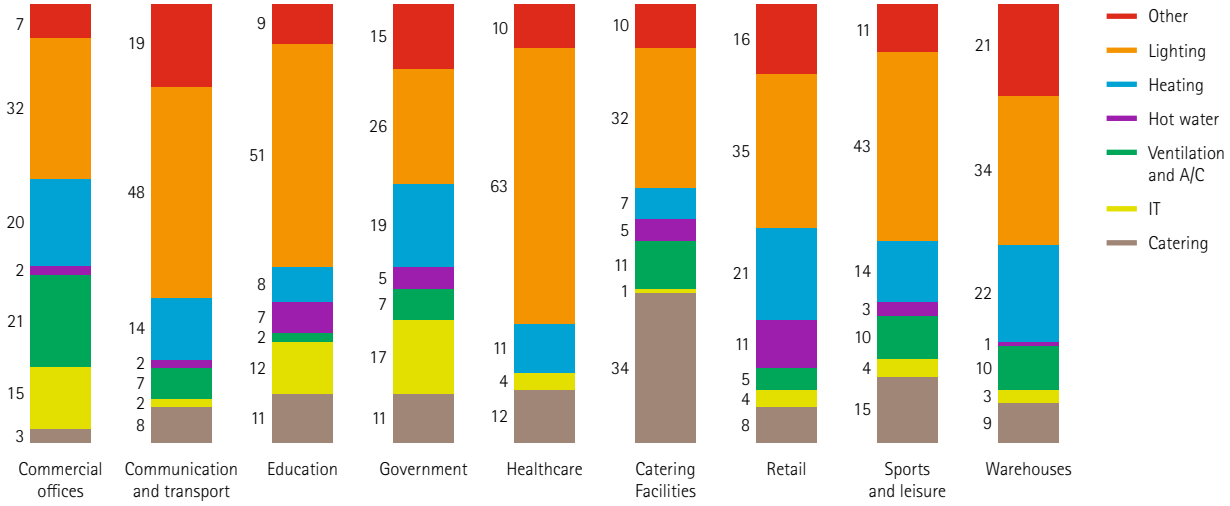
Energy prices in Europe (euro/kWh)



Source: Eurostat

light management systems savings add up from 35% for new builds to 50% for renovations *(source: New Buildings Institute)*. The IES bundled findings from 88 reference projects and reached similar findings *(see diagram at the bottom of the page)*. These percentages may of course vary. The savings potential of light management is great, but is highly dependent on the type of building, the sector and of course, the users.

Energy use per type of building



Source: Pike Research Report 1Q 2011: Intelligent Lighting Controls for Commercial Buildings

RETURN ON INVESTMENT

If in addition, we include the added value of energy-efficiency for a building, the savings are even more significant. The American real estate group CoStar gives the example of an investment in energy-efficiency of 300,000 dollars with a 3-year cost recovery period (annual savings of 100,000 dollars). In addition the investment creates added value totalling one to one and a half million dollars: a 333 to 500% return on investment!

Strategy	Savings
Motion-dependent light control	24 %
Daylight-dependent light control	28 %
Individual light control	31 %
Integrated light control	36 %
Combination of various strategies	38 %

Source: IES

3. Energy saving

ETAP uses five strategies in order to maximise energy savings. A combination of different strategies optimises the savings potential of light management.

Smart time control

Time control switches or dims the light within a building or room on the basis of calendar schedules.

Intelligent time control is especially appropriate in locations where fixed schedules are applied, such as schools or offices with fixed hours, staircases, reception spaces, etc. The light is switched on at the beginning of the workday and switched off (or in some cases dimmed) at the end of the day. It is of course also recommended to provide for individual participation (with push buttons).

Time control can for that matter also provide other benefits besides energy savings. Lyceum Het Vlier, a school in Deventer (Netherlands) switches on the lights on New Year's Eve just to scare off vandals. In this case intelligent time control contributes to the feeling of safety.

Daylight harvesting

Daylight sensors automatically adjust lighting levels, taking into account incident daylight.

When installing luminaires, the total luminous flux is calculated on the basis of the required illuminance (e.g., 500 lux in an office environment), not taking into account the influence of daylight. When daylight comes in, too much light will fall on the work surface, unless artificial light is dimmed at that time. Daylight-dependent control makes use of daylight sensors, which measure the reflection of luminance on the work surface. If the sensor is set to 500 lux, it will dim the lamp's luminous flux once illuminance is exceeded under the influence of daylight.

Light sensor ELS (ETAP Light control System), with to the right the sensor and to the left the continuously adjustable setting to control the dimming level.

Good daylight-dependent control offers an optimal balance between comfort and savings. That is why it is recommended to only partially compensate for increased luminance, in order to prevent an unnatural contrast between inside and outside environment.

Daylight-dependent light control can take place at the luminaire level (one sensor per luminaire) as well as per group of luminaires and can of course be combined with other light management systems. Additional advantage: daylight-dependent control saves most in the summer, when the thermal impact is greatest.

Daylight-dependent control adjusts the luminaire's luminous flux to the incident daylight.

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Adjustment to the task

Waste by excess lighting is prevented by setting standard lighting levels, depending on specific tasks or applications.

In an open-plan office it can be necessary to provide greater illuminance on one or more work surfaces (for example, where technical draughtsmen are at work), whilst in other locations lower illuminance is sufficient (for example, where only executive work is being carried out).

In light management systems in buildings lighting levels can be easily changed whenever the tasks carried out in the office or sections of the office change, without luminaires having to be replaced, removed or added.

Illuminance in the workplace in accordance with standard EN 12464-1

3	Offices	
Ref. no.	**Interior type, task or activity**	$\bar{E}_m$
3.1	Performance of work, copying, etc.	300
3.2	Writing, typing and reading, data processing on a PC	500
3.3	Technical drawing	750
3.4	CAD workstations	500
3.5	Conference and meeting rooms	500
3.6	Reception desks	300
3.7	Archives	200

2.5	Chemical, plastics and rubber industry	
Ref. no.	**Interior type, task or activity**	$\bar{E}_m$
2.5.1	Remotely controlled process installations	300
2.5.2	Process installations with limited manual contribution	500
2.5.3	Constantly manned workstations in process installations	750
2.5.4	Precision measurement rooms, labs	500
2.5.5	Pharmaceutical production	500
2.5.6	Tyre production	300
2.5.7	Colour inspection	200

3. Energy saving

Occupancy detection

Occupancy sensors automatically switch off the lighting when no one is present in the room. When someone enters the detection area of the sensors, they switch on the lighting.

Motion-dependent light control uses sensors that detect movement in the vicinity of a luminaire, a group of luminaires or a specific space. When motion is detected the lights are switched on. Whenever motion is no longer detected, the lighting is switched off or the lights are dimmed (after a previously set time span). A combination of both (first dimming and subsequently switching off) is also possible. Just as in daylight-dependent control, presence detection also results in extra energy savings by limiting thermal load.

In larger office or open-plan offices it is important not to lose sight of the comfort of users and prevent frequent switching or dimming to cause disruption. Here motion sensors are assigned per zone or individual luminaire sensors are connected.

When choosing sensors it is important to have a sufficiently large detection range and high sensitivity, so that the least movement is detected (for example, typing on a computer). On the other hand it may be advisable to shield a section of the detection range, for example to prevent the light from being switched on in an office each time someone passes an open door.

Kardó 90 with MDS motion sensors.

Limitation of peak load

Peak loads can be reduced by continuously monitoring the output and automatically controlling the lighting through dimming or switching.

The energy supplier often imposes fines when an agreed maximum use is exceeded. Building management can also request to limit peak loads, thus preventing overburdening. Light management systems can help to prevent exceeding (and therefore also fines) by dimming the lights when usage nears its peak. The closer peak use comes, the more the lights can be dimmed.

Given the complexity the limitation of peak loads is practically only applied through central light management. The light management manufacturer will have to determine with the customer which zones in the building are suitable for dimming. Zones where people are working, are less suitable than, corridors or lobbies, for example. It goes without saying that safety should never be jeopardised.

Since energy use in a building obviously depends on a lot more factors besides lighting, light management cannot exclude exceeding maximum use. It can nonetheless contribute significantly by levelling off peaks during use.

University of Hamburg, reading room, faculty of law: Kardó 90 with motion detectors.

4. Plan of action

The ten strategies are an excellent guide for the implementation of a light management system in any type of project. The role of the supplier is to assist both the customer, the installer and the user of the system during all project steps: planning, implementation and management.

A. Planning

NEEDS ANALYSIS

The installation of light management starts with an in-depth needs analysis, on the basis of conversations with the customer, studying the plans or examining the building.

ETAP EXCELLENT LIGHTING, SAVING ENERGY

New Project Checklist

1. Drawings (as built AutoCAD format preferred, hard copies acceptable)	Required	Preferred
Reflected Ceiling Plan (complete with light fixture locations)	X	
Furniture Plan		X
Area Usage if not contained in reflected ceiling plan (indicating area uses i.e. washrooms, office, boardroom etc)	X	
Electrical Plan		X

2. Energy Data	Required	Preferred
Supplier		X
Electrical rates or copies of utility bills (include distribution, transmission, transformer allowance, debt retirement and surcharges)	X	

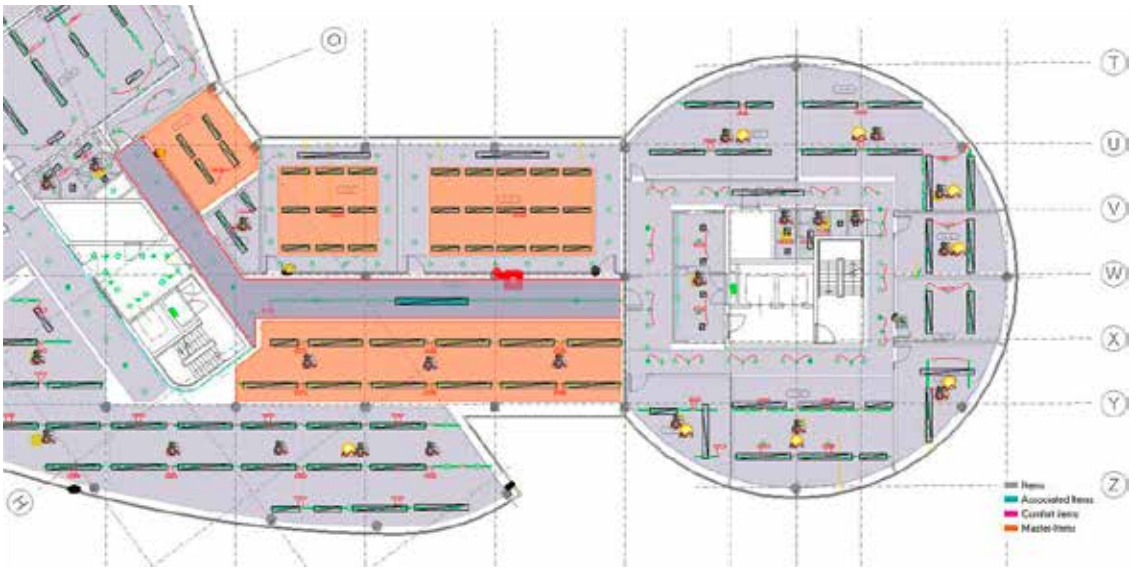
The supplier checks the various flexibility and energy saving strategies against both the building's characteristics and the customer's requirements. In a building with many outside windows, for example, daylight-dependent control will be a main part of the light management system. A company that wants to offer its staff a high degree of freedom of choice, will probably opt for personal control. In an organisation whose staff are familiar with new working practices, the focus will be on strategies that enhance flexibility.
What is especially important is that the supplier provides the customer with professional advice and discusses the various light management options with him from the onset of the project. Only in this way will the result permanently meet and probably exceed the expectations.

CONCEPT

Based on the requirements study, a concept study defines the light management in the various parts of the building. Where will daylight-dependent control be applied? Where calendar-based control? In which rooms will scenario-settings be applied, etc. This study is the basis for a budget estimate and the further detailing of the plan.

DETAILING

The concept is further refined into a detailed proposal. This includes a detailed plan with the exact positions of the luminaires, sensors and other components. In addition, the customer receives a technical overview of the system and more descriptive information about the idea behind the light management system and the applied strategies, as well as a parts list with the exact numbers and types of material and a detailed cost estimate.



A detailed plan shows the exact positions of the luminaires and all components of the light management system.

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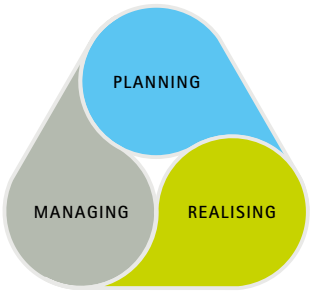


B. Implementation

EXECUTION

Support by the supplier of the light management system is also required during installation. The installer needs to be thoroughly briefed and, where appropriate, trained. Furthermore, in most cases it is recommended, prior to commissioning, to carry out the necessary tests for timely detecting and removing faults or irregularities.

After execution the installer will provide the exact plans and a detailed spec sheet, since they can deviate from the original plans and bill of materials.

COMMISSIONING

Depending on the size and complexity of the project, the supplier also supervises the commissioning of the light management system. Some settings are not pre-configured, but have to be configured on site.

Commissioning of the light management system.

C. Management

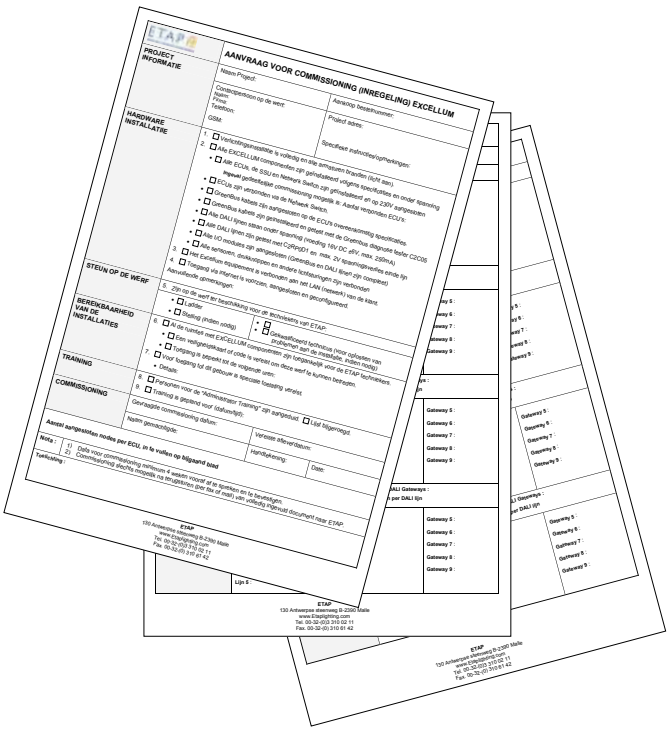
TRAINING

The manufacturer will familiarise the facility manager, building manager or technicians responsible for lighting with the operation of the light management system. Should the customer so desire, the building manager can be trained to make adjustments to the light management system. In many cases it will involve simple guidelines required to be able to carry out the most urgent operations, such as switching the light management system on and off.

SERVICES

Building or facility managers not always have the technical knowledge or time to manage and maintain the light management system. This is where a service contract can be effective. The customer is then assured of receiving direct assistance with any failure or irregularity, so that the system continues to function optimally.

An extensive service contract can also consist of a regular audit of the light management system and reporting and analysis of its operation and of the achieved savings.



5. Reference projects

ETAP has applied strategies involving light management in hundreds of projects. Below and on the following two pages you will find a limited selection.

Offices headquarters Carrefour in Paris

WHAT?
480 Thalia® RT2 luminaires with ELS (light sensor) and MDD (Movement Dependent Dimmer). These systems limit energy consumption according to the amount of daylight (ELS) and the presence or absence of persons (MDD).

THE RESULT?
30% savings (annual consumption 40,950 kWh instead of 58,500 kWh).

Mechelen Auction in Sint-Katelijne-Waver

WHAT?
Excellum light management system in a 30,000-m² shed with 218 motion detectors and 8 daylight sensors.

THE RESULT?
71% savings: 35% due to adjustment to the task, 28% due to motion detection, 4% due to individual control and 4% due to daylight control.

Schleswig-Holstein Netz AG in Niebüll

WHAT?
For maximum energy savings, Schleswig-Holstein Netz AG, a subsidiary of E.ON Hanse AG, chose R7 LED luminaires with EasyDim, which automatically adjusts the lighting intensity as a function of daylight or motion detection.

THE RESULT?
The combination of energy-efficient LED luminaires with light management allows for an annual reduction of approx. 1 tonne CO_2.

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Ernst & Young head office in Diegem

WHAT?
Excellum light management system in a five-floor office building. Integration of 700 motion detectors and 60 ELS daylight sensors. Each luminaire is addressable individually.

THE RESULT?
36% saving in energy consumption for lighting.

Jean Lévy multimedia centre in Lille

WHAT?
130 R4 luminaires with ELS (light sensor) in order to maximise incident daylight. Daylight-dependent control was the logical choice here since both sides of the rooms featured large windows.

THE RESULT?
30% savings (annual consumption 10,221 kWh instead of 14,602 kWh).

Odyzee school in Goes

WHAT?
The first energy-neutral school in the Netherlands linked its lighting to Excellum, ETAP's light management system. The building manager attaches a lot of importance to the reporting option. 'The system reports exactly how much energy is saved where, which is highly stimulating.'

THE RESULT?
A 63% saving: 47% presence detection, 7% adjustment to the task, 5% individual control and 4% daylight-dependent control.

5. Reference projects

Hausmann Berri car park in Paris

WHAT?
Relighting of the Hausmann Berri car park in Paris. Presence detectors combined with DALI ensured a multi-stage decrease in illuminance whenever no cars or pedestrians enter or exit the car park. After 2 minutes without movement the lighting level drops by 50%, after a further 2 minutes the lighting goes into stand-by mode (20% of power).

THE RESULT?
61% energy saving without loss of comfort for car park users.

Lyceum Het Vlier in Deventer

WHAT?
Lyceum het Vlier renovated its lighting installation in 2011. Lighting on the entire campus is controlled by ETAP's Excellum building management system, which leads to a 70% saving on an annual basis. Over time the lighting level had to be adjusted in one of the classrooms due to one of the teacher's visual impairment. Instead of time-consuming replacement of luminaires, the lighting level could be increased remotely, by adjusting the configuration.

THE RESULT?
Thanks to this solution the classroom did not have to be temporarily closed for renovations and no installer had to travel to the site.

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GLOSSARY

Bacnet	Building Automation and Control Network. Open standard for building management systems set up by a consortium of end users and manufacturers of building management systems.
BREEAM	Building Research Establishment Environmental Assessment Method. International quality mark to measure a building's durability performance.
DALI	Digital Addressable Light Interface. Industry standard for managing luminaires through a network.
EasyDim	Local light management system that automatically adjusts the light level as a function of incident daylight and human activity.
ELS	ETAP Light control system. Sensor with matching control that measures the light quantity under a luminaire. Depending on the total amount of light the sensor will dim the lamp: should more daylight come in, the luminaire will produce less artificial light and use less power.
EMD	ETAP Multisensor for DALI. ETAP's EMD multisensor combines the function of motion sensor, daylight sensor and IR receiver. EMD sensors can switch the luminaire on or off, but also dim it.
EN-12464-1	European application standard for lighting in the workplace.
EN 15232	European standard for building management.
Excellum2	Integrated system for light management. Combines different strategies for maximum energy savings and flexibility.
IES	Illuminating Engineering Society.
KNX	Open international standard for building automation.
LEED	Leadership in Energy and Environmental Design. International quality mark to measure a building's durability performance.
LON	Network protocol for building management, designed by Echelon.

DOCUMENTATION

- Pike research, Intelligent lighting controls for commercial buildings, ed. 1/2011
- Georg Hoffmanna, Veronika Guflera et al., Effects of variable lighting intensities and colour temperatures on sulphatoxymelatonin and subjective mood in an experimental office workplace
- W.J.M. van Bommel and G.J. van den Beld, engineers, et al., Industriële verlichting en productiviteit
- Alison Williams, Barbara Atkinson et al., Lighting controls in commercial buildings
- IES, The Lighting Handbook

U.K. ETAP NV ▪ Unit 6 ▪ Progress Business Centre ▪ Whittle Park Way ▪ Slough ▪ Berkshire SL1 6DQ
Tel. +44 (0)16 28 55 96 50 ▪ Fax +44 (0)16 28 55 90 12 ▪ enquiries@etaplighting.com

ETAP Export Department ▪ Antwerpsesteenweg 130 ▪ B-2390 Malle - BELGIUM
Tel. +32 (0)3 310 02 11 ▪ Fax +32 (0)3 311 61 42 ▪ export@etaplighting.com

www.etaplighting.com

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