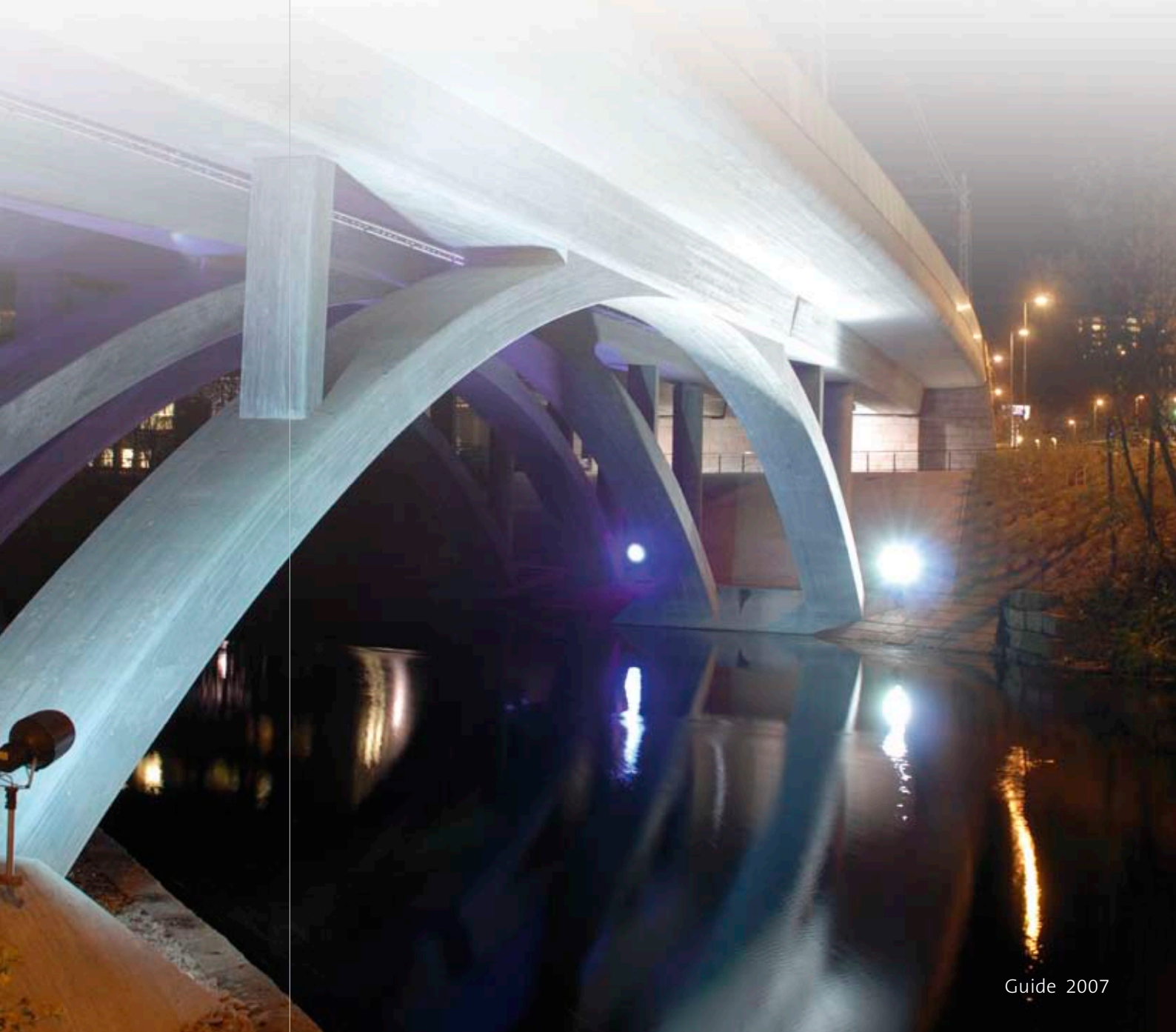
Guide for energy efficient street lighting installations



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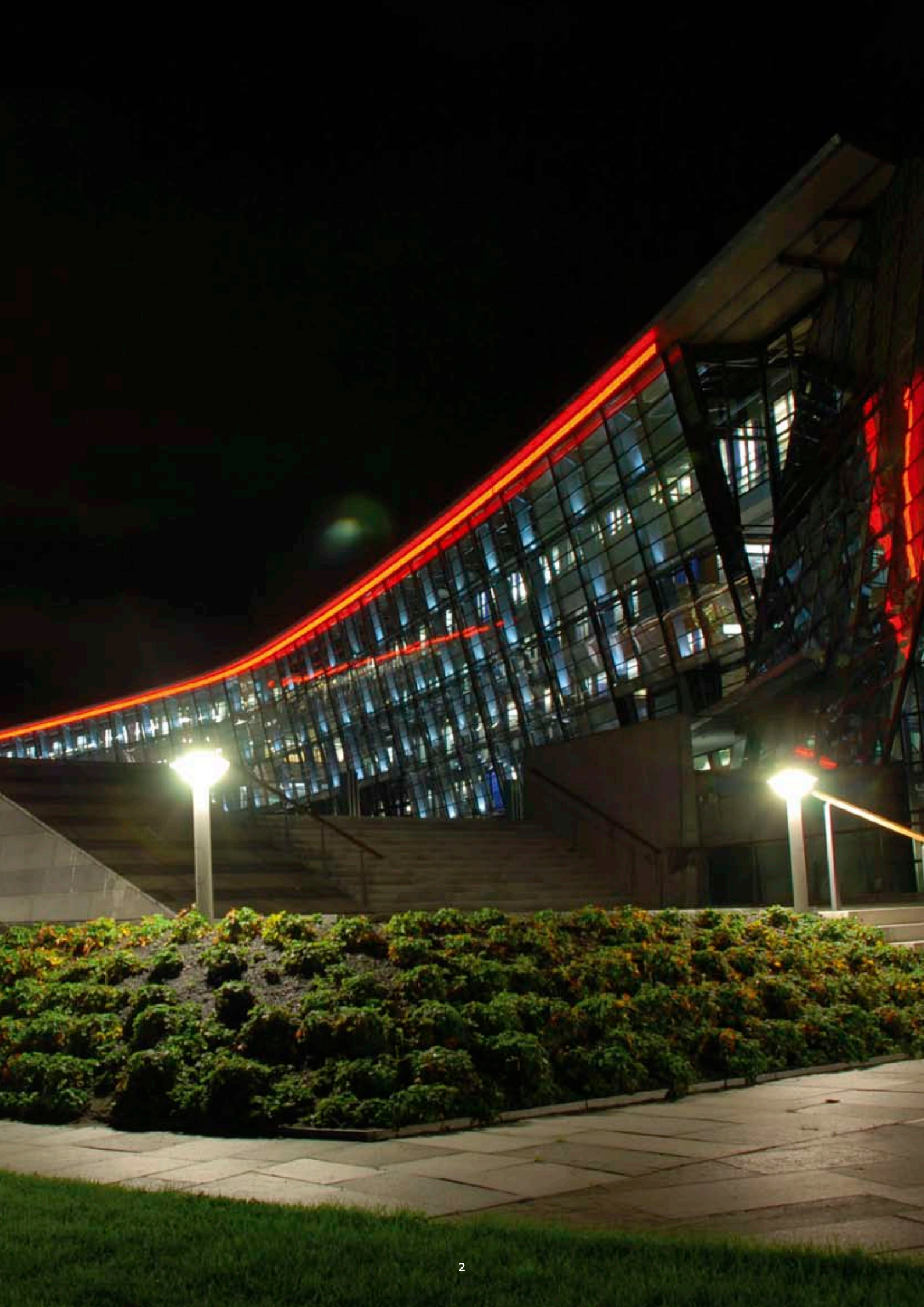


Huge savings potential

Huge saving potentials utilizing new technology. Outdated installations increase energy costs and new technology represents a large cost cutting potential in the rehabilitation of outdoor lighting installations. With new installations there is great saving potential when employing new enriching adaptive lighting techniques which are possible with today's high technology.

Old installations inflict unnecessary yearly costs. By correct investments and utilizing today's technology it is possible to reduce today's energy consumption for street and road lighting by as much as approximately 60 %. For Europe as a whole, this stands for about 36 TWh a year. In addition, you also achieve a significant saving on maintenance costs.

Recently there has been a tendency towards a shift in the responsibility for costs related to installation and operation of street lighting installations. In Norway this came as a law reform in 1991, the law stated that it is no longer allowed to make cross subsidies of street lighting within the electricity companies. This means that the road keeper have to cover all the costs related to installation and operation of the street light.

There are several factors that emphasize the importance of a holistic focus when considering investments in these kinds of installations.

Normally public authorities have two different budgets for running and maintaining the installations as well as investing and construction. This does not make it easy for overall consideration of the installations total economical aspects. This is also applicable to adaptive lighting where re-investments, in some cases, can have a "payback time" as short as 5 years or less.

When sending out a tender, there is today a public demand that all purchasing and contracts should be in accordance to existing laws of public purchase. It is also important that the tender gives a thorough description of what functional demands should be addressed in a lighting installation, so that afterwards you can choose the best total solution in terms of both investment costs, running costs and maintenance costs (ref. LCC).

As much as 50-70 % of the original energy consumption can be saved by reinvesting in new technologies where old in-efficient luminaires have been replaced, changed lighting arrangements and the introduction of stepless dimming in relation to adaptive lighting and as much as 70 % in energy reduction has been achieved. By replacing the luminaires only, between 40-50 % energy reductions is achieved.

In addition, by implementing two way communication (luminaires with built-in intelligence), you achieve an accurate feedback on the lamps condition and thereby reduce the need for manual control, and may plan maintenance in a cost effective way. To keep a better track of your installation and secondarily to optimize the priorities for the maintenance of the road, the road keeper should have an electronic record of his installations, based on a digitalized mapping system where each component is registered as individual traceable objects with a geographical reference.

This booklet is meant for personnel with responsibility for outdoor street lighting, road keepers and advisers/ consultants.

Crossover subsidies:
To transfer costs for running the electricity grid to cover costs for installation and operation of street and road lighting installations.

LCC-calculations:
A calculation that show the resulting cost over the installations whole lifetime or a closer specified time period.

Objects /attributes:
Information stored with a registered geographical position such as a luminiare with attached GPS coordinates (X/Y).

Organizing outdoor lighting

Road and street lighting place heavy demands on the public road budget. Recent studies in Norway indicates that the daily costs represent about 20-40 % of the total budget, half of this figure covers the energy costs and the other half goes to running and maintenance.

Example:
Trondheim municipality budget 2006:

Luminiares:
1100 at highways
2800 county roads
16600 mun. roads
300 parks
700 private roads
Total 21500

Budget:
Run/maint: 925.000 Euro
Energy: 950.000 Euro
Reserves: 6.250 Euro
Total: 1.881.250

Road lighting specifications:
Specific regional demands for building and erecting of road lighting, here you can implement both technical, esthetical and functional demands. As well as other guidelines to be followed.

Examples of functional demands:
Lifetime
Material
Colour
Connection/interface
Maintenance need
Colour rendering
IP-classification

It's important that the road keeper has control and awareness of the costs. It's being observed that some road keepers try to reduce their costs by transferring the responsibility to private road keepers and community associations. A complicating factor with such a solution, is that many of these installations are constructed and integrated with the main supply grid. It can therefore be the case that one installation contains several customers. For instance in Norway, the Public Road Authority, ("Statens Vegvesen") is the road keeper in all of the municipalities.

Road lighting guidelines
By writing such guidelines for the diversion of responsibility gives better control for your costs.

When introducing guidelines you should also consider making the establishment of road lighting an obligated part of the allowance for constructing roads in the municipality.

The guideline can describe the correct work method for securing quality and these should follow the municipalities' general regulations of road construction. This paper will then represent a minimum demand for (private) initiated installations to be connected to the public grid.

The guideline should consider the following subjects:
* Description of public measures. Where the municipality has made a political or administrative decision for the initiator to include road lighting as an obligated and included cost for the road construction, the cost for new establishment will be transferred to the initiator.
* The quality standards for luminaires and technical equipment must be described (see notes)
* The municipality should define the desired level of lighting on the road in accordance with international and national regulations with recommendations and set limits for the use of energy related to defined luminaires.
* Considerations of light pollution issues should be described
* Describe which parameters should dictate when to switch on/off the luminaires and under which conditions the installation should operate at dimmed levels.
* Where in the existing grid system it should derive power. For installations with two way communication, describe the requirements for the communication equipment and define the protocols for communication to the administrative system.
* Specifications of correct integration points for energy measurements. (How will the energy consumption of the installation be measured?).

With the rapid development of luminaries and lighting control gear it is of great importance to keep the guidelines"up to date".

Accomplishing public demands
To comply with the regulations concerning the removal of hazardous PCB from lighting installations, it is especially important to emphasize to the responsible authorities the energy saving potential that can be achieved by upgrading the technology of their installations.

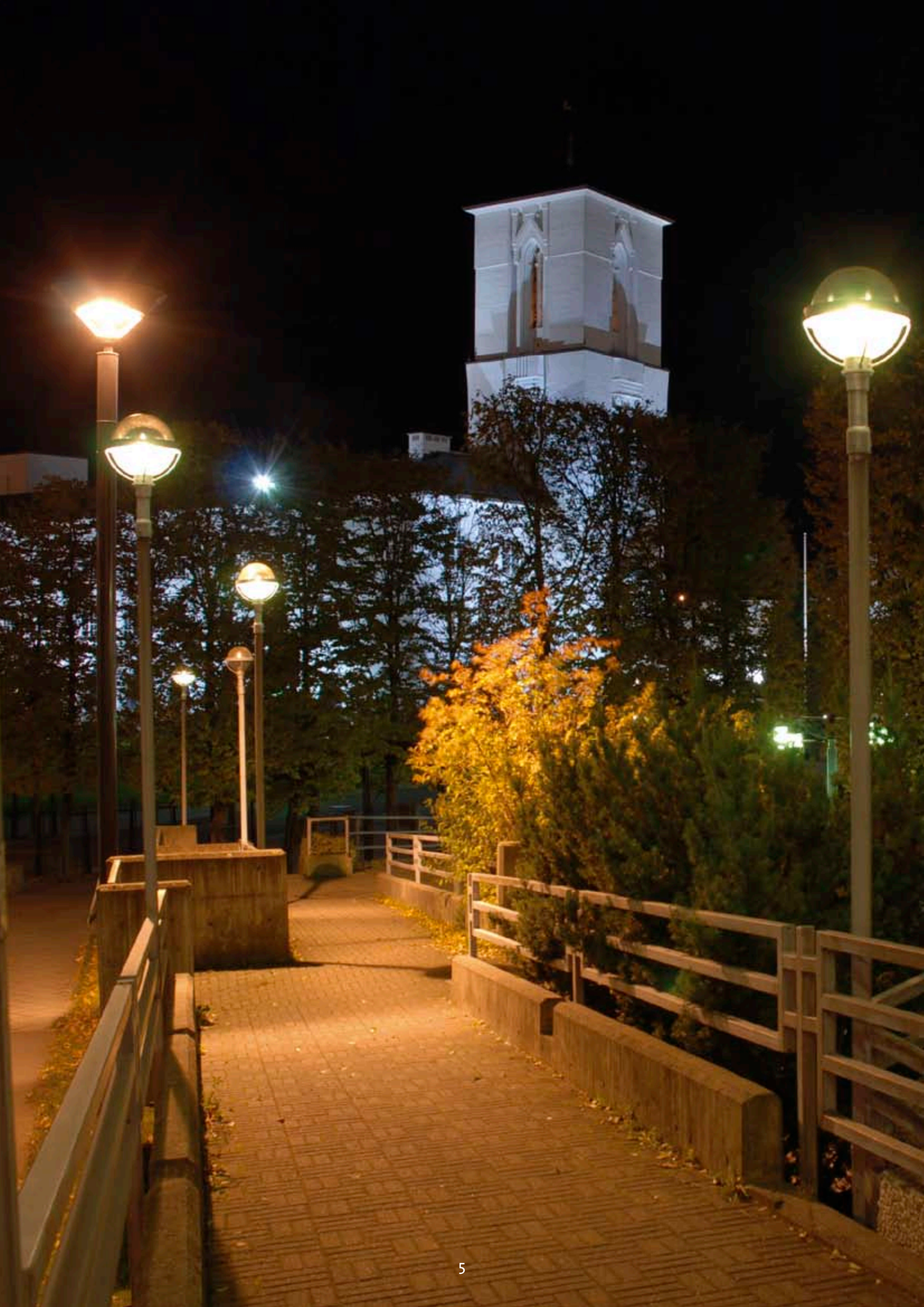
New installations have to comply with today's regulations for lighting levels, electrical installation regulations and environmental demands.
The proposed EU "ECO-directive" also sets demands for the "lifecycle analysis", lead and mercury free installations and a ban against ineffective electro-mechanically control gear. **Let your new lighting installation be a class A installation!**

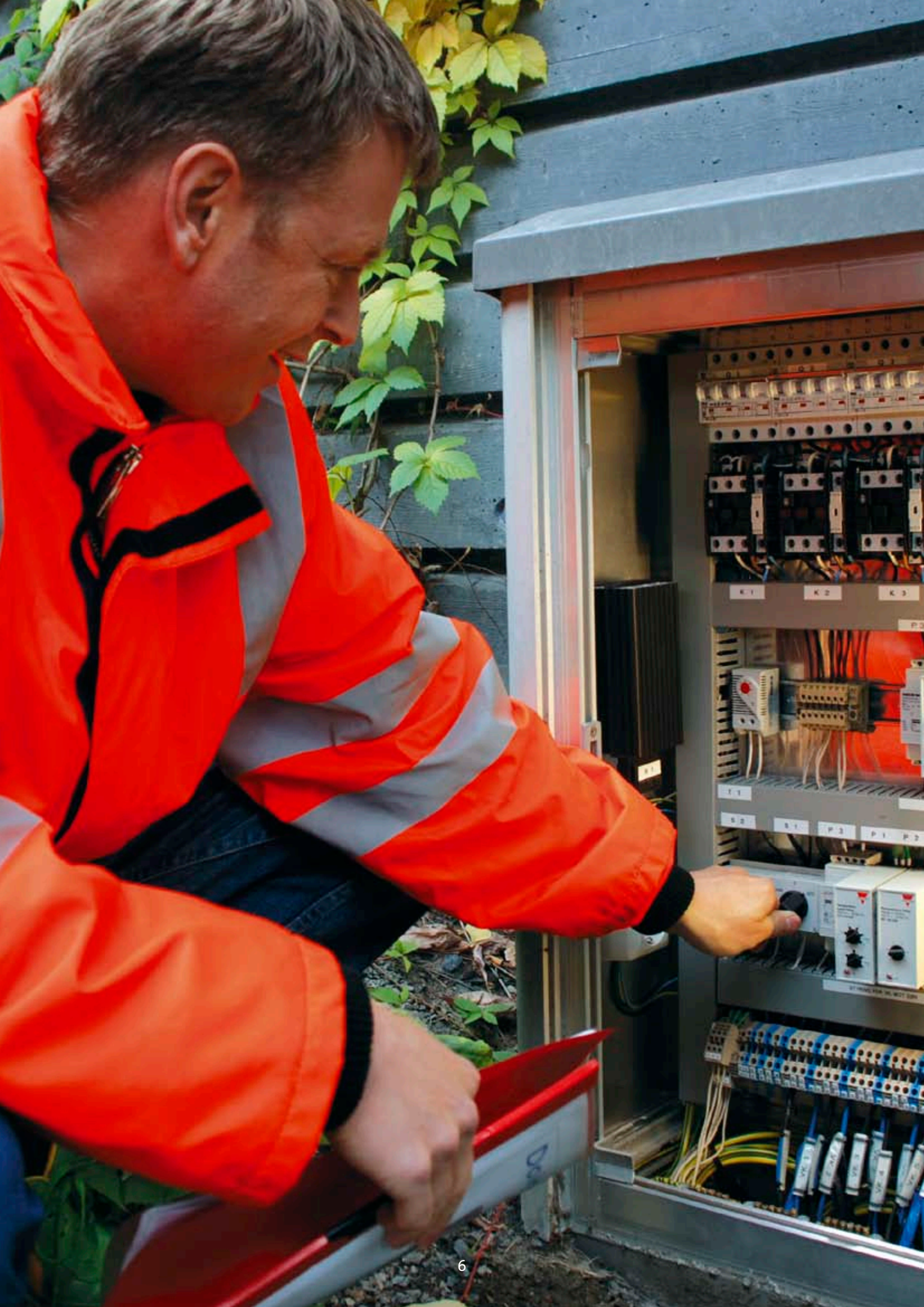
By implementing these changes you prepare for future European recommendations and regulations concerning the environment and the energy reduction.

Financial considerations
The calculation of return on Investment is important to identify today's energy cost, including the cost of both electrical power consumption and of energy used. Furthermore a lifecycle calculation will have to consider the future changes in cost. The calculations will use the "present value method" with discounted cash flow or by the use of continuous cash flow analysis. For the calculation of financial costs or of financial payback, the public rate of calculation should be utilized.

By utilizing new types of luminaires and control gear you can prolong lifetime values so that the annual maintenance costs is reduced.

In total one could say that by reinvesting in new technology and planning according to today's lighting level demands, the road keeper will achieve a payback on invested capital within a time period of 4-6 years depending on the initial situation; energy price level, and the level of maintenance costs involved. (Whatever the situation this is a short payback time compared with other safety improvement measures.)





How to get started?

For existing installations it is of high importance to be aware and have control of the existing installation. For new installations and refurbished installations one has to make optimal lighting choices taking into consideration the roads complexity, traffic volume, way of construction and the volume of pedestrians and cyclists.

Remember: The evaluation of alternative solutions sets the groundwork for good results!

If there isn't an already working guideline for the installation to comply with, the installation has to be built according to the relevant national and international regulations. Check whether today's infrastructure (columns, electrical grid etc.) is still applicable? Is there a clear understanding between the road keeper, electrical supplier and any other parties (phone company, estate owner etc)?

In this concern there are several publications worth considering (see notes). Eventually the installation has to be evaluated and designed with regard to the technical specifications, both lighting values and electrical requirements by using computerized programs.

Being aware the current technical developments you also should consider how your new installation should be monitored, controlled/regulated, and maybe integrated with digital maps.

It's of great importance to make an overall strategy plan on the organization of the everyday running and maintenance operations.

By calculating the costs for different solutions it's important to know today's cost for by instance each luminaires. If a higher financial investment is made today so that stepless dimming is implemented, then this will lower energy costs and provide a potentially longer interval between each luminaires replacement. Furthermore, one will be able to plan and use personnel resources more efficiently by utilizing handheld computer solutions such as so-called "fleet control".

One will also have to put some thought into how to exploit the modern technology to reduce the costs for everyday running and maintenance of the existing not upgraded installations.

There is therefore a need to use a calculation model (LCC) that calculates the alternative solutions affects on equipment-, installation-, energy-, running- and replacement costs, as well as the general maintaining costs. The respective elements have to be calculated with its corresponding lifetime expectancy and cycles.

CIE - 115
Recommendations for the lighting of road for motor and pedestrian traffic.

EN13201-2:
Road lighting. Performance requirements.

Fleet administration:
Administrative data management of operational tasks that makes economical overview related to planned actions possible.

Do the old installations fulfil the current electrical guidelines?

What is the average lifetime of the luminiares?

Is it possible to implement energy measurements?

Upgrading installations

Upgrading of outdated installations. Throughout Europe you find miles of outdated installations. Today this represents an enormous energy saving potential, and at the same time in many situations, do not solve the lighting task in a satisfactory way. New technology represents new possibilities.

Remember: Retrofitting of old installations can utilize up to 50-70% energy reduction, in addition there are reduced running costs!

Introducing new technology does not necessarily demand a reconstruction of the electrical supply. For instance existing technology can utilize the existing power distribution grid for communication, in addition to radio and digital mobile communication (GPRS/GMS).

When new luminaires are retrofitted it is found that lower power consumption is used to achieve the original lighting levels on the road.
New luminaires contain both better optical systems and lighting sources that contribute to more light for less electrical energy, and also contribute to less light pollution (obtrusive light) by directing more of the light onto the road and not the surroundings. An installation designed using the old standards, also has a higher averagely lighting level compared to today's needs. These improvements in technology allow us to consume less electrical energy and at the same time to achieve adequate road lighting.

Light pollution:
Too high levels of light or light in areas where it's not wanted.

As the implementation consumes reduced energy then the existing electrical infrastructure is more than capable of supplying the retrofitted luminaires. Since the retrofitting does not involve the electrical grid, the implementation of a control system that demands a separate communication cable will result in a bad return of investment.

On the other hand there are alternatives for the feeding of communication. Both radio communication and the so called "PowerLine communication", are alternatives that do not require any physical connections in addition to what already exists.

The main principal is to install a component in the feeder cabinet that communicates, two-ways, with each and every one of the luminaires either by radio waves or by communication signals on the existing power grid.

The component located in the feeder cabinet can be programmed to control and log every luminaries on an individual basis (in some situations only the component in the feeder cabinet can contribute to a significant better control and feedback from the installation, without the upgrading of the luminaries). With this technology one have the opportunity for individual energy logging and updated information on running/maintenance that will contribute to an easier planning of the daily maintenance.
A considerable reduction of the municipalities costs for running and maintaining the road lighting installations will be the result of such an investment.

Adaptive lighting:
Description of a lighting installation that automatically adapts to the needs; for instance the weather, road conditions or traffic demands. For optimized usage it takes built in intelligence in the luminiares that makes two way communication possible.

Intelligence:
In this context means the "built in" electronics in the luminiare that can measure and control the luminiare and makes two way communication possible and thereby achievement of "adaptive lighting" (also called "intelligent lighting").

The future is adaptive lighting

Take control of your streetlighting

Public guidelines for purchasing have to be followed!

Adaptive lighting

Adaptive road lighting. Road lighting is present to increase the safety of traffic and to enhance the sense of security for individuals. Previous regulations and guidelines were designed to use the technology that was available at the time.

The basis for all road lighting engineering has been to maintain safety by being able to observe objects on and beside the road. Important factors are the roads geometrical design, complexity, traffic volume and speed.
One also has to consider wet surfaces, the presence of pedestrian crossings, parked vehicles, schools etc. All installations were designed in the past based on the worst case scenario which is still valid.

The photoelectric detector was considered as a revolutionary development at the time, and is present in most road lighting installations today. As new technology can adapt the light levels steplessly, new possibilities arise.
Modern technology for supervision of the traffic will optimize the lighting, it will also still need to cater for the worst case scenario but should also be able to automatically adapt fully to the current needs. For example if the traffic flow is low during the night or if the traffic speed is low during rush hours, or in snowy conditions the reflection from the road surface is so high that the need for lux levels is considerably lower than during wet or dry conditions and so on.

The obvious advantage of using adaptive lighting, with built in intelligence, is reduced energy consumption and reporting from the lamp of the current status. This gives better control of the installation and ensures that the equipment actually delivers what is required to the customer which leads to an improvement of the quality of the delivered product, "road lighting". This can be used to deliver higher quality form the installer organisation. It also makes possible to achieve better fleet management.

Better control also gives increased predictability and secondarily it lowers maintenance and running costs, by being able to achieve better planning and better implementation of error corrections in the installations. Adaptive lighting introduces demands for better energy measurements in the installations allowing the automatic regulation of both electrical parameters, burning hours and light levels. This will call for a demand for measured installations where metering is not installed today. How this is to be included must be a part of the agenda when an installation is being carried out. If the same system implements the measurement function and the control function then the communication expenses will be reduced, it will minimise the number of components needed in the system so reducing costs and simplifying the operation and maintenance.

Purchase – an important function

Good planning will ensure the foundation for a good lighting installation. Your decisions will have consequences for more then 20 years into the future, so this obligates a thorough planning phase. This can mean the need for independent and high quality competence in this phase.

For new installations and refurbished installations it is important to ensure that the tender has an accurate and precise technical description that at the same time doesn't favour any "brand specific" technology. At the same time it's important to end up with an installation that in the future can function well, without being dependent of any single supplier or contractor. A good example is to use standard lamp sockets (by instance E27 or E40) and ballasts that can ignite different types of lamps (by instance both metal halide and high pressure sodium lamps).

When the project initiator is provided with a good description of the technical functionality this goal is obtainable. When carrying out large investments and/or implementing a "framework agreement" it is also important to give the administrative system some thought.
This system can embrace the control of the installation, gathering of information on energy consumption, log the burning hours of each lamp, link burnt out lamps to a superior mapping system and many other useful functions concerned with documentation and the daily running of a streetlight installation.

Often it's also the road keeper's job to deliver lighting for parks, pathways, floodlight tracking tracks and so on. It's important to consider individual demands for these lighting tasks also.

In Norway public purchasing is obligated to include a Life Cycle Calculation (LCC) when deciding a purchase. The tender therefore has to specify clearly how these calculations are to be carried out. This will include information on the total efficiency of the system, power loss in the ignition system, efficiency of the lamp, expected decrease of maintenance costs due to extended life times etc.

Lighting measurements terms:

Illuminance:
(Lux)
Is the total incident light (luminous flux) on a spesific surface, per unit area.

Luminance:
[Cd/m2]
Density of reflected or emitted light from a surface in a spesific direction, per unit area. In road lighting the important factors are the roads reflecting ability and the amount of incident light. This is the most used quality criterion in streetlighting today.

Glare:
Light that either reduces the comfort or directly reduces the vision. Maximum requirements are given for streetlighting installations.

Contrast:
A measure of the visibility between an object and the background (or another object). The higher contrast the higher visibility.

Uniformity:
Relative number that indicates the relation between the lowest luminance level present and the average luminance level present in a defined measuring field. Minimum requirements are given for streetlighting installations.

Lighting calculations

Lighting calculations can initially seem quite simple to perform using today's computer based calculation programs. But it takes an experienced lighting planner to make correct assumptions and premises, and also to interpret the results. Normally several adjustments have to be made before you receive an optimal result.

It's important to perform genuine calculations for your installation.

During rehabilitation it's important to consider lamp heights and possible "extended mounting brackets". By switching from old mercury lamps to high pressure sodium lamps it is often possible to decrease one "step" of the installed lamp effect (W) and still provide for today's demands for lighting. In these situations lighting calculations should be carried out with an independent counsellor.
With a new installation lighting calculations are to be documented so that all demands are being fulfilled.

When building new installations you are free to optimize your installation dependent on lamp height and relative placement of the columns.

Which demands are to be met when carrying out lighting calculations?
- Independent of the supplier
- Adjustments to the present road geometry and surface
- That it uses the same lamps in the in the planned installation as those used in the calculation.

When ownership is transferred/accepted, measurements should be carried out on the installation to verify that the actual lighting level relates to the deliverable lighting calculations!

Support schemes

For the financing of this kind of projects it is possible to gain financial support from both national and international organisations. Below the European program IEE is shown.

Intelligent Energy – Europe (IEE) as part of the Competitiveness and Innovation Program (CIP) (2007-2013)

The objective of the IEE II Program is to contribute to secure, sustainable and competitively priced energy for Europe, by providing for action:

- to foster energy efficiency and the rational use of energy resources;
- to promote new and renewable energy sources and to support energy diversification;
- to promote energy efficiency and the use of new and renewable energy sources in transport.

It will in particular contribute to the Commission's proposed integrated energy and climate change package including the renewable energy road map and the Energy Efficiency Action Plan.
Intelligent Energy – Europe II (IEE II) builds on the experience gained from its predecessor, the first Intelligent Energy - Europe (IEE) Program running from 2003 to 2006. This Program has become the main Community instrument to tackle non-technological barriers to the spread of efficient use of energy and greater use of new and renewable energy sources. IEE II should also help with faster and smooth implementation of energy-specific legislation.

For tender specifications and call for proposals visit:
http://ec.europa.eu/energy/intelligent/index_en.html

IEE:
Intelligent Energy Europe

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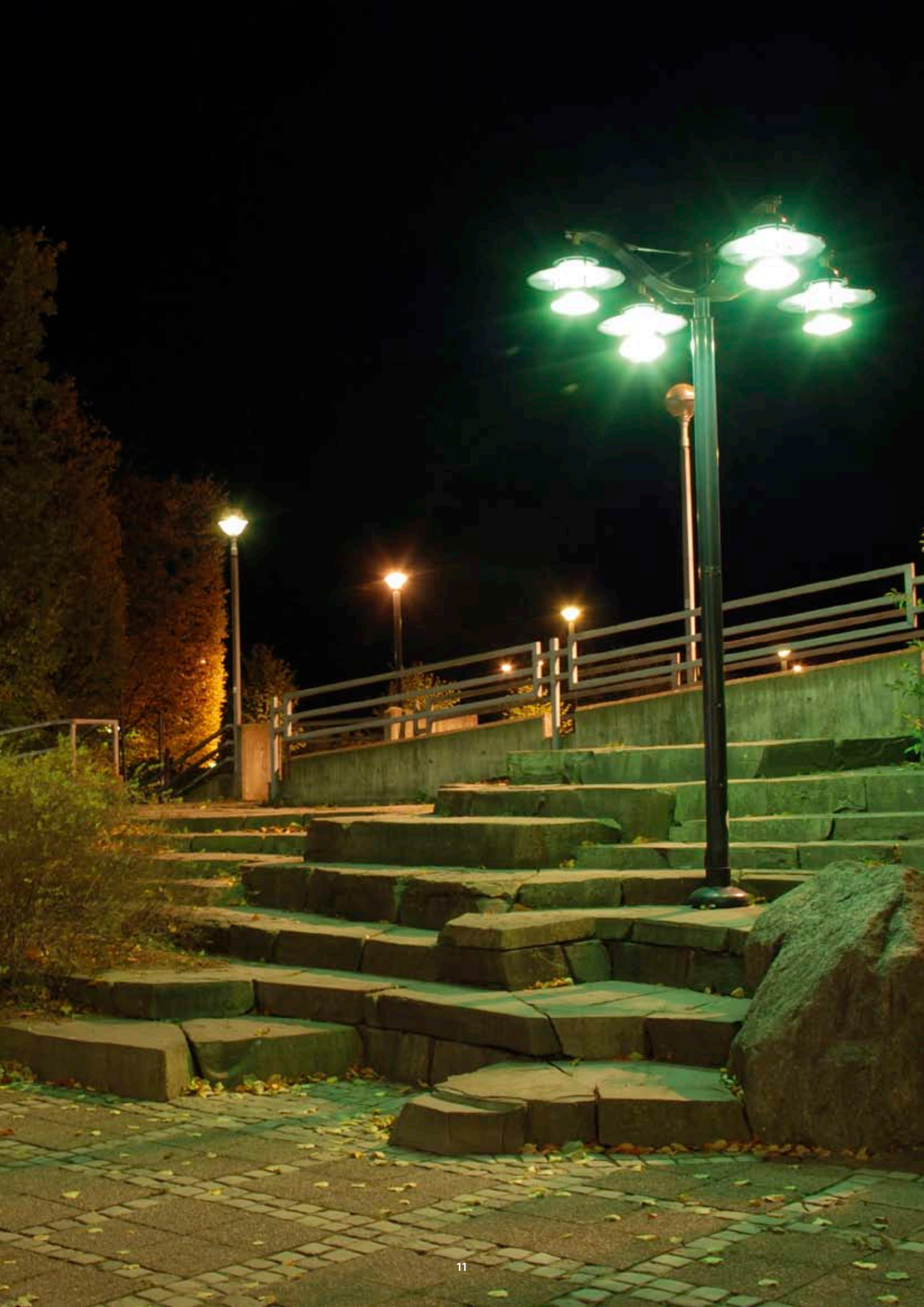

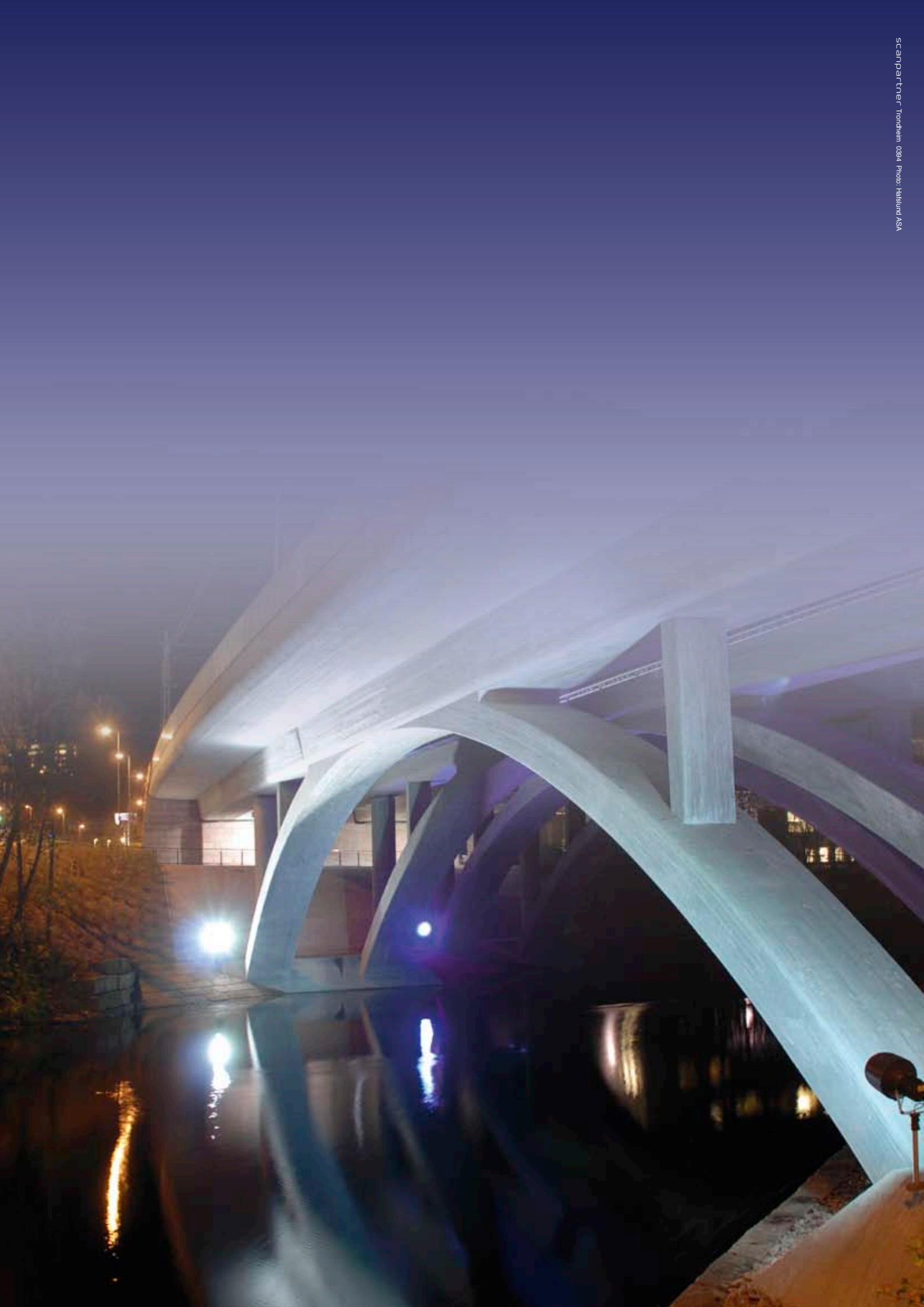

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