E-street Initiative

Work Package 2

Market Assessment and Review of Energy Savings

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On behalf of the E-Street project (www.e-streetlight.com)

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Intelligent Energy Europe

Table of Contents

1. Introduction

Telemanagement is all about Market Assessment and Review of Energy Savings for outdoor lighting systems. In this document I have provided an overview of what we think is a realistic estimate of the energy savings that can be accomplished in Outdoor Lighting Systems by implementing new technologies available to us today. We have also described the additional benefits that implementing new telemanagement systems bring on top of the energy savings. In calculating the total savings potential for Europe we had multiple discussions on the total number of outdoor lights in Europe since this number is an estimate. Other estimates in the energy calculation are the divisions in lamp type and mix of installed base in luminaires since this information is not available. Using the experience of the E-street members and the market data from lamp and ballast manufacturers I believe these estimates are accurate.

The second part of the report deals with the environmental aspects of outdoor lighting and the positive impact that replacing older systems by new manageable systems can have on the environment. This is a non-quantitative description of the subject. Dimming and using better luminaires are discussed as well as the positive impact that removing hazardous chemicals has on the environment. An interesting contribution to this subject is about the increase of safety by managing outdoor light.

Legislation is different per country but there are some common denominators that are used throughout the entire EU. They are listed in a separate chapter. Per item there is a short description given on the subject of the legislation and how it impacts management of outdoor lighting.

The market blueprint in this report gives an overview of the different types of players in this market and the solutions offered by them. It discusses the various roles of the companies involved and explains their interest in this market. As part of this chapter we have assessed the changes that will take place in this market and the new players that will enter because of the developments that are taking place.

Last but not least, as in any initiative, there are barriers to overcome and this chapter defines the ones we found. An interesting part in this chapter, is about the lack of knowledge and the advice given to overcome these barriers.

The report is also based on the contributions of the E-street participants and the knowledge we collectively have about (managed) outdoor lighting. The possibilities that exist today are implemented in a growing number of installations both on highways as well as in cities. Telemanagement of outdoor lighting gives us a significant opportunity to save energy and decrease the environmental impact outdoor light has on our environment.

2. Documentation of Energy Savings

Street lighting in Europe today is a mix of technologies that have been available in the market for the last 30 - 40 years. Needless to say that in most of the earlier technologies the energy efficiency was not considered a design goal. The development in lamps, ballasts and luminaires over the last years have focused around the efficiency of these critical items in an outdoor light system and as described in this chapter already give significant saving opportunities. Existing installations are a mix of new and old technologies. We estimated the ratio of this mix based on the market input from major lamp and ballast producers and the market data that exists.

Over the last years new technology has been developed and implemented in multiple systems that can help to save even more energy; telemanagement. Networking and automation technology allows for the adjustment of light levels to the exact need to keep the roads safe based on weather conditions, traffic density and other external factors. Telemanagement systems also account for significant savings in maintenance and increased safety because they instantly report failures in the system. In this chapter we have taken this information into account.

LED lighting also has great potential to help save energy in outdoor lighting. However the technology is still in the development phase and there is relatively very little experience with it at the moment. We wrote this report to document what we know today about outdoor lighting technology that can be deployed today. For this reason we have not incorporated the opportunity that other light sources (e.g LED) will lower the energy consumption even further in the future.

2.1 Estimate of the energy used for street lighting in Europe today

Below is a best estimate of the total energy consumption in Outdoor Light for Europe. The assumption is that we have 725 million people living in Europe including the Russian republic and Turkey.

The number is calculated based on the best estimates we can execute, given the current information available to us.

2.1.1. The number of light points

First of all we calculated a best estimate of the total number of outdoor light points (not on private housing) that can potentially be improved by replacing parts of the system or by upgrading the total system to use new energy efficient technology and telemanagement.

The number of light points has been estimated based on luminaires market data available from various large companies in the industry. The data from specific countries indicate a relation between the number of inhabitants and number of light points for street and road lighting.
The most accurate data came from Germany where the total number of outdoor light points is known. The total number for Europe has been recalculated based on information from various E-street members.

For each 9 inhabitants we find there is 1 light point on average. The example from Germany shows 82 million inhabitants and approximately 9 million street light luminaires installed. Based on the information from other countries this is found to be

a high number to apply to all of Europe since other countries (and cities) show lower numbers of luminaires per person.

Weighing all information available we estimate for Europe, with 820 million inhabitants, that the total number of outdoor light points is 91 million.

2.1.2. The average installed wattage

The wattage used in road and street lighting varies typically between 50 and 400 Watt. Based on the market and production data we have from a large lamp manufacturer we know that a smaller number of countries in Europe traditionally have high output wattage levels and the rest uses an average or lower level.

Estimate and vendor assessment of the total market for relevant lamp types and wattages indicates that the average wattage for lamps used in road and street lighting is 180 Watt. This number includes the losses in the ballast.

2.1.3. Average burning hours per year

Burning hours vary because of the geographical natural light situation. Interestingly enough we find that on average the calculations used do not show significant changes between northern and southern European countries. Normal calculation of burning hours without dimming and switching on/off based on the remaining daylight level is 4150 hours per year on average throughout Europe.

All calculations for Dynamic Outdoor Lighting System in this report are based on this average of 4150 burning hours per year.

2.1.4. Average burning level

The most important issue when applying dimming in a dynamic outdoor lighting system is the fact that the safety needs to be guaranteed. The influence on the safety on the road is hard to quantify because it consists of accident prevention as well as crime prevention. There is legislation on various levels per city, per country and on a European level that in many cases is based on a non-dimming situation. Currently the CIE is working on a proposal for new legislation taking the possibilities to calculate safe light levels based on weather conditions, traffic density and hours of the day. This is not yet ready and cannot be used as part of this report.

Saving as much energy as possible, means switching off and dimming light levels when ever possible. One has to make sure that this is in accordance with the regulations. At all times it needs to be possible to go to a full 100% situation if the circumstance requires this. In some recent installations switching of every second luminaire or dimming when there is low traffic density is already installed but the number of installations where this is deployed today is so small that in this report we assume it does not significantly influence the current energy usage. We have therefore decided not to use a modifying factor for this type of savings measures in our calculation.

2.1.5. Outdoor Lighting energy consumption in Europe

Based on the estimates we discussed the total energy consumption for street and highway lighting in Europe can be calculated as follows:

80 million light points x 180 W lamp wattage x 4150 burning hours per year:

59.760.000.000.000 Watt hours = **59,760 TWh per Year**

2.2. Overview of energy savings possibilities per system part

An outdoor lighting system consists of various parts that could contribute to energy savings when replaced by products that improve the energy efficiency. Below is a description of the various single opportunities that exist and can be deployed today.

In existing street light systems it is also wise to see if improvement can be reached by renovating the power supply system. Other things that can influence the efficiency e.g. cabling, transformer, or the load division across the phases are not within the scope of this report and will not be discussed.

When replacing components in the outdoor lighting system it is wise to look at the overall solution. Dimming luminaires for example influences spacing as uniformity.

2.2.1 Lamps

Over the years the efficiency of lamps has improved significant. In this paragraph we describe the various lamp types available today. Based on market data the estimated mix of existing lamp types is covered.

The most common lamp types used for street and road lighting:

High-pressure mercury vapor lamp
High-pressure mercury lamps are one of the most common types used in outdoor lighting, first used in the early 1960's. This lamp is very inexpensive and lasts around three years. It has a good voltage "tolerance" and burns universally. It is extremely energy in-efficient and contains mercury. Mercury lamps provide white light.

Low-pressure Sodium
This lamp type is commonly used in the BENELUX and the UK. The first installations with this lamp date as far back as the early 1930's. It is very energy efficient, lasts for around three years and contains no mercury. There are various disadvantages with this lamp. There is no color rendering witch lower the distinctive capacity for the road user. It is rather large in size what causes a lot of the light to be wasted because it is hard to focus it. The lamp has a long run-up time what means it needs to be switched on earlier than necessary. Low-pressure Sodium lamps provide a monochrome orange light.

High-pressure Sodium
This lamp is very energy efficient and lasts up to four years. The lamp is optically efficient but shows a long run-up time. It has limited color rendering and does not allow for retro-fitting. In some version of the lamp mercury is used. High-pressure Sodium lamps provide a orange/yellow colored light.
Metal halide
Metal halide lamps are based on the latest technology and trends in street lighting. They are very energy efficient and provide a high quality white light. There are various types of metal halide lamps suitable for street lighting including the CDO-TT and CosmoPolis lamps. With CosmoPolis the miniaturization of the lamp and the gear has made it possible to use smaller luminaries with better optics that allow for bigger spacing. The total cost of ownership is low because of the long life time.

These lamp types offer significant environmental advantages because of very low mercury levels and the energy efficiency.

2.2.2 Energy saving based on lamps

At present approximately one third of the European roads and motorways are lit using energy in-efficient 1960's technology with mercury vapor lamps. These lamps consume a relatively large amount of electricity during their lifetime with limited efficiency. In addition they contain mercury and are therefore environmentally unfriendly.

By shifting to High-pressure Sodium lamps or Metal halide lamps efficiency improvement in the lamp itself an go as high as 40%. This could reduce total energy consumption for street lighting for Europe with approx. 15% taking into account 1/3 of the installed base is really old. A normal replacement would be from 250W to 150W means 40% reduction per lamp. Shifting all lamps (also the newer types to most efficient lamps could reduce energy consumption another 5 -10%. The total energy saving potential in lamps used is therefore approx. 20%

2.2.3 Luminaires

The luminaire development over the last 30 years has focused on improving the optical performance made possible because of the characteristics of the new lamp types.

Ovoid opal lamps with a large volume and low relative luminance can now be replaced with clear small lamps with high luminance.

This development in lamp size and the characteristics in optical design mean that the efficiency of modern luminaries can be 25 – 30% higher than those based on optical systems for old ovoid lamps.
If all street lighting luminaries in Europe were updated to the latest luminaire technology with high optical performance, the energy saving potential is estimated to be around 15%. Of course we need to take into account that the savings can only be accomplished in combination with new lamps.

2.2.4 Ballasts

Arc discharge lamps such as fluorescent and HID sources require a device to provide the proper voltage to establish the arc and to regulate the electric current once the arc is struck. This is what the ballast does. Ballasts also help compensate for voltage variation in the electrical supply.

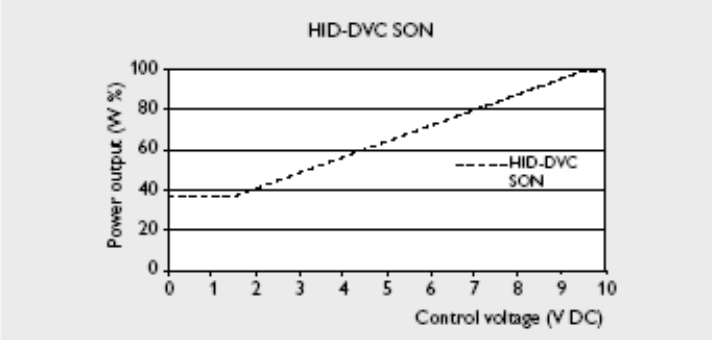
The technology for ballasts is changing rapidly from magnetic to electronics ballast. Magnetic ballasts use coiled wire and create magnetic fields to transform voltage. Magnetic ballasts do not change the frequency of the power to the lamp—it remains the same as the input power.

Electronic ballasts use solid state components to transform voltage. It also changes the frequency of the power from 60 Hz to 20,000 Hz, or higher, depending on the ballast. Because the electronic ballast doesn't use coils and electromagnetic fields, it can function more efficiently and cooler than magnetic. The frequency change also greatly reduces any flicker in the lamp due to burn in or improper power.

The availability of reliable power electronics makes it possible to build more electronic ballast for different applications.

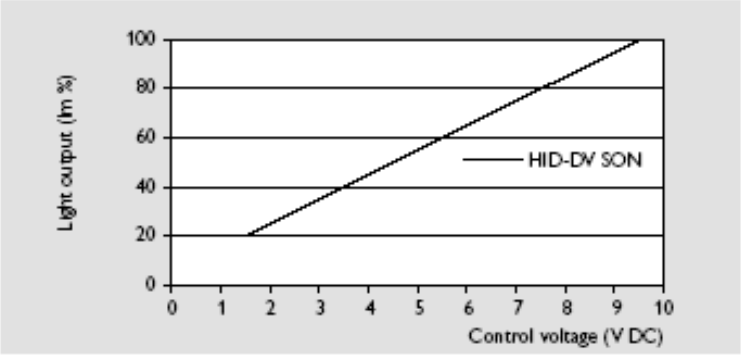
Description of most common types of ballasts used for street lighting

Below are two graphs of dimmable ballasts from Philips as an example for the control voltage output as a function of the power output. Plus a second graph that shows the light output as a function of the control voltage.



Relationship between light output and control voltage

Example for Dynavision Controller 400W



Relationship between light output and control voltage

Example for Dynavision Ballast 150W

2.2.5 Energy saving possibilities based on ballasts

The system of precise electronic power control extends the lamp life by 30 % while reducing power consumption by about 7%. On top of this electronic ballast give the opportunity to provide for the possibility of stepless dimming.

In many cases the dimming level is set by an external module that communicates with the ballast's control interface. Today there are three types of control interfaces known:

1-10 Volts controlled
A ballast with 1-10 v input dims the output according the voltage level of its set point input in a range of 1-10 volts (1 volt means minimum level, 10 volts means maximum level). To switch the light on and off the power to the ballast is interrupted.

DALI controlled
A ballast with DALI input dims the output according to digital commands encoded in the DALI protocol (Digital Addressable Lighting Interface). By using a DALI protocol the ballast can switch on and off without the need to interrupt the power. DALI also enables other data from the ballast to be communicated to the controller for example for the purpose of burning hour calculation.

Proprietary controlled
There are various ballast manufacturers that provide for their own proprietary interface limiting the freedom of choosing the ballast separate from the controller.

The dimmable ballast plus controller gets it commands from an external module (segment controller) normally situated in the feeder pillar cabinet. This unit communicates over Powerline or RF to the actual controller in the pole. This brings us to the next paragraph on managed outdoor lighting better revert to as Telemanagement.

Another technology of dimming outdoor lamps is by regulating the voltage level for the entire segment at the power supply cabinet. This technology is not reported on in this project because it is not considered to be optimal for energy savings.

2.3 Dynamic Outdoor Lighting Control Systems "Telemanagement"

The best name for systems that do dynamic outdoor lighting control is probably Telemanagement systems.

A Telemanagement system enables the lighting system to automatically react to external parameters like traffic density, remaining daylight level, road constructions, accidents or weather circumstances. The data communication on the street level can be based on the LonWorks Powerline communications protocol that supports a large number of media which makes integration with complex traffic management and geographic information systems easier.

Public lighting managers have known that they could lower the operating costs of their systems if they could cost effectively collect the critical data needed to make better planning and operational decisions. Lighting engineers have conceived of new designs to improve public safety and reduce energy consumption only to be stymied by an inability to economically control every luminaire in the system.
Without a suitable network to gather the information and exercise control, these designs could not be implemented in a public lighting system. Today power line based communication networking can achieve significant operating and energy cost savings while improving both the reliability and the quality of public lighting systems. In combination with IP technology it is relatively easy to build a Dynamic Outdoor Lighting Management or "Telemanagement" System.

This network approach when based on an open network standard enables many manufacturers' devices to share the same network and provide data across a single infrastructure. Many applications can then be used to manage the public lighting system-effectively expanding the value of each installation. A communication network that is open would enable monitoring, control, metering and diagnostic applications that can transform the economics of operating public lighting systems.

If this network is also available to monitor the age and condition of every lamp, that information would eliminate the guesswork inherent to cost benefit calculations. Decisions could be made with confidence that the real-time data from the public lighting system supported the return on investment.

Furthermore, the Telemanagement system can be used to monitor failed lamps and report their location, maintenance expenses (materials, routing, labor, etc.) could be minimized by considering the remaining life of nearby lamps that might be replaced during the same service call.

Finally, data collected by the Telemanagement system that tracks the hours of illumination for each lamp can be used to claim warranty replacement, establish unbiased product and supplier selection criteria, and validate energy bills for the system.

Telemanagement based on a Powerline communication network is cost effective today for monitoring, control, metering and diagnostic applications that save energy, reduce maintenance costs and improve system reliability.

So apart from the energy savings realized by dimming the light to the level required Telemanagement systems have significant other benefits that will be discussed in this chapter as well.

2.3.1 Description of a Telemanagement system

A Telemanagement lighting system that makes for a compelling return on investment and provides the benefits listed above can be largely achieved today with the integration of “off-the-shelf” products. The system consists of 3 main parts:

The Outdoor Luminaire Controller
First of all a luminaire equipped with dimmable light sources is an important part of the system. The basic set-up is a lamp and dimmable ballast in combination with a controller for this ballast. We call this controller the Outdoor Luminaire Controller (OLC).

The lamp system controller is the component that forms the link between the dynamic lighting system and the lamp. Because it is possible to have many different types of link between the lamp system controller and the ballast, standard interfaces have been selected as described before: 1-10V or DALI. This allows products from different manufacturers to be used and exchanged.
OLC specifications:

- (stepless variable) dimming
- switching (on-off)
- possibility to measure lamp operating data (nominal data as a basis for alarms)
- predictive behavior function based and status indication
- monitoring of ballast and lamp data of including:
  - lamp status (on/off/dim position)
  - burning hours
  - number of starts
  - electrical characteristics including operating voltage system
  - power consumption and electric current
  - fault and status indication
  - data, communication problems, lamp fault and ballast fault
- maintenance operation is necessary for the OLC for testing
- work autonomously as an active communication repeater in the system
- continuous communication monitoring with action (lamp to 100%) in the event of communication failure;
- implement programmed actions following an alarm for example reduce lamp voltage after a ‘near end of life’ alarm.

For practical reasons it would be desirable if OLC are to be used for 'conventional' applications, i.e. as switching/dimming/communication units for existing lighting luminaires with conventional ballasts.

The Segment controller

The luminaires are connected to a power supply cabinet and communicate with the Segment Controller (SC). This basic infrastructure part consists of an intelligent controller that handles various functions like scheduling/control/data logging and alarm handling per segment as well as the WAN communications to the over all management system. The segment controller is the main part in the local lighting installation and should be based on open technology so it is possible to easily modify or expand on it in the future. The following specifications are based on systems currently available in the market which all have at least the following in common:

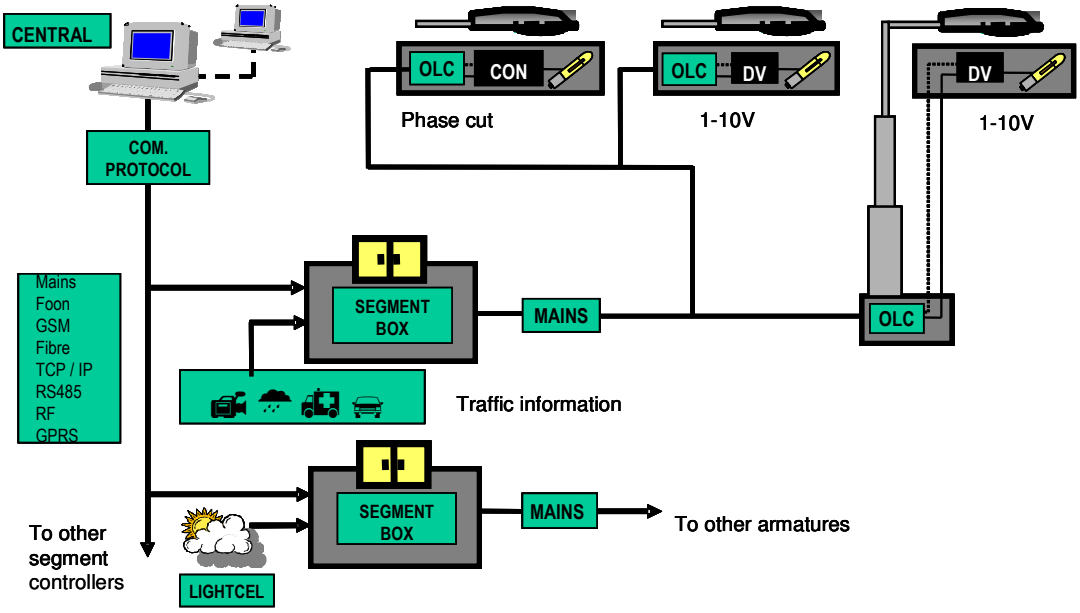
- the segment controller must work as a network interface with repeater management functions, a web server, and have the option of accessing an ANSI 709.2 network from an IP networks and/or the Internet independent of the underlying infrastructure
- the segment controller must be able to log alarms, act in response to alarms and prioritize them. When at last precipitation or accident situations are present the result must be a signal to set 100% lighting.
- There should be embedded calendar and scheduling functions for both absolute as well as astronomical clocks
- Availability of web server functionality and the capacity to access and program functions based on SOAP/XML (Simple Object Access Protocol) and customized web pages
- automatic collection and logging of data from connected OLC's
- capability to automatically upload new software and data to the OLC following an update from the central system or a local update without the need to be online
- the management, processing and implementation of inputted scenarios and clock programs including the option of bypassing these functions
- availability of digital inputs and outputs including relay control. Possible applications include
  - door open/closed contact;
  - pulse counter (kWh);
  - external alarm report outside cabinet;
  - linking in of additional external triggers.
- availability of IP (Internet Protocol) network interface an ANSI 709.2 (Local Operating Network on the street side) interface to various communication carriers and protocols;
- availability of option to link in a GPRS module and/or modem or any other ADSL modem

The central management system

The central management system is used to control the segments and manage the data coming from the segment controllers. This third and very important part of the system is what we also call the IT interface. When there are two or three segment controllers in the network it is very easy to manage them, but very quickly it becomes impossible to do this manually when the number increases. Specifically if the segment controllers reside in different locations, with different service providers and different WAN connection types it rapidly becomes difficult to manage.

The software solution in a telemanagement system should allow for the management of the system as well as for using the data in an existing IT environment. They functions this interface provides are the following:

- It manages the WAN communications. It keeps track of where the segment controllers are, what the service provider is. How you can reach them and how healthy they are.
- It collects the date from your segment controllers. It keeps track of when the data was collected, if all data was collected and if the right data was collected.
- It organizes and stores the data coming from the equipment. Terabytes of data are collected over a year and if one needs to search for it , it needs to be organized and stored in a structural way.
- It synthesizes new data. The field data is usually not in the right format and not the information needed to take fact based decisions. Users are not interested in pulses but in the amount of kWh used. The number of burning hours is one, but what really interest's a person is when to replace the bulbs. The recalculation part of the system needs to do that work.
- And last but not least the data needs to be used in existing IT applications. For example the possibility to reflect the life situation in a GIS system needs is important but also billing and maintenance information where service providers have already existing systems.



Overview of the system configuration

The system needs to remain functioning even if the central management system is failing or the WAN communication prevents it from sending control messages to the segment controller. This is possible because the system consists of a network of decentralized intelligence in the segment controller and even in the OLC for automatic operation. Using this "distributed intelligence" means that no central controller is needed to allow the system to function efficiently and safe.
The OLC's check the lighting, either by using information from ballasts or by using extern signals. The remaining of the system can keep functioning autonomous if one of the components or a part of the system fails.

2.3.2 Telemanagement system functions

The required functions for telemanagement system differ from user to user. However there are several basic functions the system needs to perform to be able to perform the basic tasks needed for optimal energy savings.

Dimming
Lighting level requirements often depend on external parameters such as traffic volume, ambient brightness and weather conditions. When there is very little traffic on the road drivers do not require the light level they need when the traffic density is high. One can imagine that the weather situation influences the visibility as well and in return the light level needed. To avoid rapid changes around these switching criteria the system must smooth out these changes (hysteresis).

Energy saving by dimming on time, traffic density and weather conditions.

Demands to the light intensity often depend on external parameters, such as traffic intensity, daylight, road constructions and weather conditions.

These factors may vary at different points in time, different seasons or a combination of both.
Therefore it is not an optimal solution to maintain the same illumination intensity for a pre-defined period. There is no need for the same light intensity if there is very little traffic with a clear sky on a dry road. Regulation of the light level based on the desired situation can easily be realized with the Telemanagement system.

There are some ground rules that apply that are listed below:

Precipitation, slipperiness and fog sensors
Precipitation is a local phenomenon. Therefore it must be detected locally, that is once in every weather section. A weather section is several kilometers long. A precipitation switch is installed, unless a good visibility meter is available, which can also detect precipitation

Slipperiness data are obtained from a Slipperiness Detection System. Because of the local character of slipperiness, it is not necessary to install additional sensors for this but the telemanagement system needs to anticipate the situation.

Fog is detected by visibility meters. In areas where fog detection is available, the available sensors will be used to set lighting levels.

The switching criteria currently used for dynamic lighting are:
- precipitation: presence of raindrops (precipitation, heavy precipitation)
- slipperiness: presence of slippery conditions as detected
- visibility: visibility 140 meters

Energy saving by dimming to compensate depreciation factor

When planning a new lighting installation a maintenance factor is taken into account because of the reduction in flux of the lamp during its lifecycle. Therefore, depending on the lamp type, a new installation or an existing installation, right after re-lamping, may produce up to a 20 % light excess. With telemanagement it is possible to reduce this effect to 0 by dimming based on the actualised lamp database to correct for this gradual reduction of light flux during the lamp life.

This is called the CLOU function (Constant Light Output) and may count for up to 10 % of the total energy consumption depending on the lamp type. There is no negative effect on the service, safety or comfort for the public. Next to the evident economical advantages, these options mentioned above will also contribute to the reduction of light pollution and energy consumption.

Stepless dimming allows adjusting the lighting level down to approximately 40 - 50 % of the flux accounting for energy savings of around 30- 40%.

Similarly there is little point in the esthetic illumination of monuments in city centers in the early hours of the morning. The same goes for office buildings in industrial areas in the weekends. There are no numbers available on the energy savings this will bring.

Main financial benefits of telemanagement

Telemanagement goes beyond issuing commands and obtaining feedback. Up-to-date information at all times enables you to forecast and plan with far greater accuracy leading to more effective maintenance and a reduction in time use.

Adding a Telemanagement function for example to an already scheduled lamp/ballast or luminaire upgrade can dramatically improve the payback on the investment in the following ways:

1. direct cost reductions through dimmable ballasts and networked controls: Controlling light intensity to correctly engineered levels throughout the lamp's entire life to minimize energy consumption as described above
2. direct cost reductions through measuring each lamp's energy consumption at the fixture
    a. this enables for detecting lamps that are nearing the end of their economic life and replacing them prior to the excessive energy consumption that occurs in lamps prior to burning out
    b. It eliminates excessive wear on the ballast and starter caused by lamp cycling that usually results in replacing the fixture or gear rather than just the lamp if undetected
3. direct cost reductions through a centralized database that integrates data from the control network with a wide area network, (such as GPRS), in turn making the data available to central office GIS software
    a. contains timely status information on every fixture that the GIS-software then links to standardized location co-ordinates. The result is alarm messages from the fixtures and their precise locations can be easily combined into optimized maintenance and refurbishment route plans with an estimated 30% increase in efficiency.
    b. graphical User Interface to the city-wide GIS system can be used to detect power outages and inform the utility, create ad hoc lighting schedules for special events or prioritize the response to safety critical alarms such as ground faults
4. direct cost reductions through embedding intelligence in each control device can deliver diagnostic information with alarm messages
    a. reporting the exact repair needed, with customized instructions, and even the replacement part number to the technician eliminates spurious lamp replacements and minimizes time on each job
    b. Interfacing with software applications that generate work orders, order spare parts and manage inventory reduces the total amount of labor time per repair across the organization. Cost savings can be achieved in many parts of the enterprise as a result of data integration

   c. expensive and time consuming methods of scouting and visits are no longer required
   d. the urgency of the failure can also be determined, the urgency to take direct action (on critical places) the possibility to wait and organize a combined and therefore cheaper intervention
5. creating a “closed loop” system essential to lower inventory levels of spare par
6. direct cost savings because of the longer life expectancy of the lamp circumstances present in real life do sometimes deviate considerably from the conditions under which the lamp’s data, such as service life expectancy have been calculated (especially fluctuations in the electricity grid). A combination of electronic “constant wattage” ballasts and Telemanagement ensures one that these differences are almost eliminated. In practice this brings a significant increase in the lamp’s service life expectancy, which will reduce the maintenance costs.

A significant portion of any lamp or ballast replacement program is installation cost. By installing “network ready” control devices at the same time as a new lamp, additional savings in energy, maintenance, and public safety can be achieved. The benefits of networked controls exceed the minor initial installation costs.

Example calculation

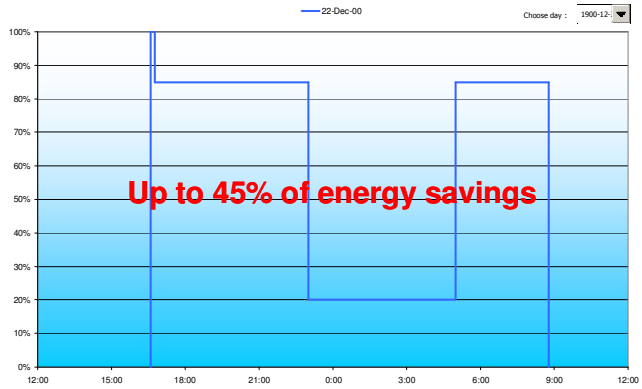
The pay back period of the initial investment in telemanagement will have to be analysed case by case and is studied in another work pack. It depends on a large number of factors as might be clear from the above mentioned. In summary it is essential to take the required dimming period, the possible reduction in flux, the price per kilowatt hour, the potential reduction of early lamp failures as a consequence of voltage peaks etc. Furthermore, the pay-back period strongly depends on the current practices in managing the installed base.

The first approach is to consider a regular outdoor installation like for example a highway with 1000 light points of 150 W lamps each.

Switching and dimming based on astronomical clock scheduling.
This is the most common way to dim outdoor light. The scheduler depends on the real geographical position of the system (each cabinet will have his scheduler and will control an approximate number of 100 light points) and adapted to the sunrise and sunset in that location. Therefore you have more savings during winter than in summer.

ENERGY SAVINGS	**Telemanagement**	**No TM**	
Overall Installed Power	150	150	**kW**
Annual working hours	4.150	4,150	**h**
Annual energy consumption	622.500	622,500	**kWh**
Annual energy saving (kWh)	280.125	------	**kWh**
Annual energy saving (%)	**45**	------	**%**
Light Points	1,000	1,000	

Energy savings with telemanagement



2.3.3 Real life example

In Oslo There has been over the last years done 3 test/retrofitting-installations on telemanagement systems.
Starting back in 2003 with 120 luminaries, next installation was 2000 luminaries in 2004, and finally 4400 luminaries in 2005.

The below figures are relative numbers for the installation done in 2005. The retrofitting was done in the north eastern area of Oslo city, including both rural living areas, industry areas and some collector roads.

The old installations were in some cases a bit over dimensioned and we could in some cases (approx 5 %) go from dual-sided lighting down to single-sided lighting. For the project area the old installation had an installed power of 677,8 kW divided on 4500 luminaries this results in an average lamp output of 150,6 W (without losses included).

As mentioned the retrofitting installation contained 4400 luminaries representing 444,3 kW of installed power. In average this represents 101 W per luminarie and a reduced installed effect output of 34,4 %.

2.4. Conclusion on energy savings

In conclusion it is possible to reduce the amount of energy used significantly going from an old to an entirely new situation. Replacing the lamp, luminaire and ballast will account for about 37% reduction in energy consumption.

Telemanagement in such an installation can be as high as 45% off this number when applied fully bringing the total energy savings up to about 66% of a conventional older installation.

Based on our total consumption calculations this means for Europe that we can save as much as 63.7 % on our energy consumption in outdoor light what would mean an annual saving of 38,06 TWh.

3. Environmental aspects

There are various points we have to consider when talking about environmental aspects in street lighting and the modernization of it. In this chapter we covered the aspects that in our opinion are the most important:

1. Light Pollution
2. Removal of hazardous substances
3. Lifetime increase of components
4. Crime reduction (although it is questionable if this is environmental)

It is clear that saving energy is a huge benefit to the environment mainly because of the reduction of CO2 emission. This will not be discussed in this chapter.

3.1 Light Pollution

In many areas light pollution has become an important aspect of both planning and design of road light systems. Neighborhoods are becoming more sensitive to the stray light that is being directed towards their property and windows. Astronomers and observatories are becoming more concerned with the increase in the sky glow around urban areas. Environmentalists are getting more concerned by the impact of light on nature. Specifically the attraction to animals and insects is of concern.

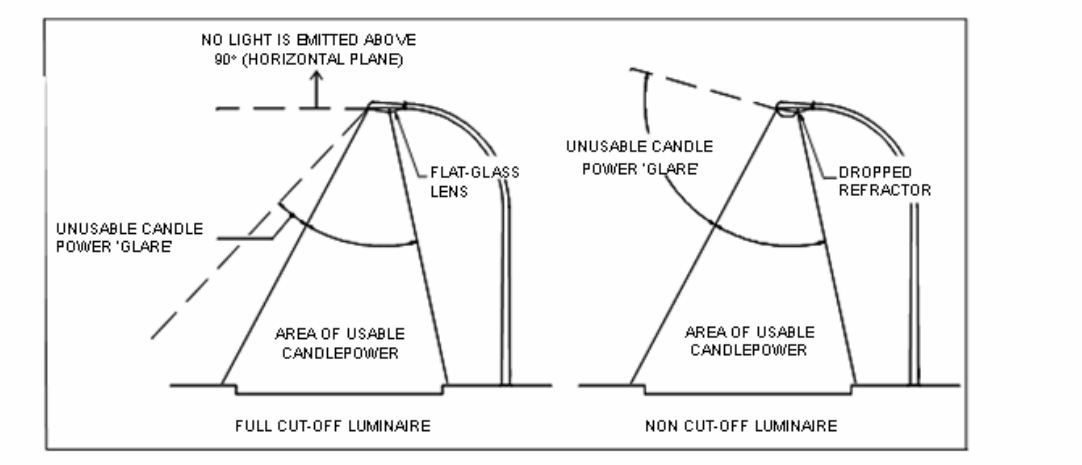
It has been estimated by some researchers that up to 35 - 50% of all light pollution may be the result of roadway lighting. This makes it an interesting subject for this report.

There are three major issues when looking at light pollution and some minor ones. The most important are trespass, glare, and urban sky glow. There are also some minor issues like annoyance, clutter and confusion as well as the fact that in many instances poles and other structures along the road are necessary to put the light on that imposes traffic danger but these will not be discussed in this chapter.

3.1.1 Luminaires

There are various type of luminaries and depending on the type used they have a bigger or lesser impact on the environment. The basic shapes for the luminaire and classifications are defined in terms of vertical and lateral light distribution as well as the control of distribution above maximum candlepower. This is known as the cutoff. Vertical and lateral light distributions apply primarily to the shape of the area to be illuminated. Both of these distributions can be important when determining the amount of light trespass from a source.

A non-cutoff fixture allows the light to be distributed easily so that the light is aimed less precise while a cutoff fixture allows for better aiming and therefore better glare control. The design with cutoff fixtures is therefore a lot more precise than with non-cutoff. It is clear that the non-cutoff luminaires have a much bigger impact on the environment than the cutoff type.



Effect of cutoff and non cutoff luminaires

The standard for roadway lighting is listed in ANSI/IES PR-8. This list gives the minimum requirements for the safety of roadways and therefore influences the light pollution factor a lot. Below is a table with these values.

Road type	Luminance
Urban freeway	10
Freeway Interchange	14
Commercial Arterial	20
Residential collector	8
Local	6

3.1.2 Light Trespass

Light trespass is the effects of light or luminance that strays from the place that it actually needs to light up. It goes without saying that on a road it is desirable to have as much light as possible aimed at the road. Poor quality lighting fixtures, which are generally of a non-cutoff type allow the light to fall on areas away from the road such lawns and houses. People are upset by the stray light that enters their property or windows. Related problems are also known to drivers and aircraft pilots.

The use of new lamps in combination with new luminaires with better optics helps to prevent this problem. Of course it is important to take the road and application into account when designing the light system as well.

The use of a telemanagement system where the light is dimmed to the minimum required level depending on weather and traffic density has a very positive effect on light trespass.

3.1.3 Glare

Glare can be described as unwanted light source and is normally categorized into three areas. It is IES as the sensation produced by luminance in the visual field that is sufficiently greater than the luminance to which the eye has adapted to cause annoyance, discomfort, or loss of visual performance and visibility. The three categories of glare are described as follows:

Blinding Glare: So intense that for some time after the light source is removed no object can be seen or distinguished. This is for example the effect when an oncoming driver forgets to dim the high beam headlights.

Disability glare: Glare that causes reduced visual performance. Disability glare is also known as 'veiling luminance' and is cause by the effect of the luminance of a source illuminating the inside of the eye in which the light rays are scattered or reflected within the eye reducing the contrast of images on the retina. Disability glare can cause serious problems in a roadway lighting system. It reduces the drivers ability to distinguish objects clearly.

Discomfort Glare: Glare that causes discomfort or annoyance without necessarily interfering with visibility. This effect is subjective and not easily quantifiable although several countries have applied some limits to the amount of discomfort glare permissible from a lighting system.

The reduction of glare is based on the same principle as the reduction of light trespass. It is necessary to use well designed luminaires that points the light at the right places. New modern technology has a better ability to reduce glare than older luminaires.

Also here the use of a telemanagement system where the light is dimmed to the minimum required level depending on weather and traffic density has a very positive effect on glare.

3.1.4 Urban Sky glow

Urban Sky glow is the effect we get from all the stray light plus the direct light emitted the horizontal plane. Many of the poor non-cutoff luminaires emit up to 10% of their light above the vertical angle of 90 degrees, with up to 30% of their light above a vertical angle of 80 degrees. Full-cutoff luminaires on the other hand emit no light above 90 degrees and considerably reduce the contribution to sky glow.

The use of full spectrum lights such as mercury vapor and metal halide emit high degrees of ultraviolet radiation what is another problem. The use of high pressure sodium lights emit a more monochromatic light has this problem less.

Urban Sky Glow has been difficult to quantify. Again the use of telemanagement and dimming greatly reduces Urban Sky Glow especially at times of low traffic.

3.1.5 Conclusion

Artificial light can be a nuisance, we sometimes need it to safeguard and enhance our night-time environment.

We are now beginning to tackle the problems of light pollution. A number of organizations are campaigning against light pollution, including the Campaign for Dark Skies (CfDS), Government departments, local town and county councils. Lighting designers, manufacturers, engineers and architects are beginning to appreciate the need to reduce light pollution.

We can reduce the extent of light pollution with a number of simple measures:

- designing light fittings that reduce light emitted upwards
- positioning lighting properly and directing it downwards
- using only the necessary amount of lighting – employing dimmable ballasts
- Switching off unnecessary lighting, particularly decorative floodlighting and advertising lighting, late at night and in the early morning.

3.2 Removal of hazardous substances

When modernizing and replacing a street light system today is it wise to replace with RoHS compliant products.

PCB

Before EPA banned the manufacture of PCB's in 1978, PCBs were used a lot in the manufacturing of light ballasts. The use of PCB's in ballasts manufactured prior to 1978 was not regulated by the EPA. All light ballasts manufactured since 1978 which do not contain PCBs should be marked by the manufacturer with the statement "No PCB's". For those manufactured prior to that time, or for those ballasts which contain no statement regarding PCB content, you should assume that they do contain PCB's. If the ballast does contain PCBs, it is located inside the capacitor. If the ballast fails, the capacitor may break open, allowing the PCB oil to drip out of the fixture. The capacitor does not always leak when the ballast fails, but when it does happen, measures should be taken to limit or avoid exposure.

In Norway we have a so called PCB directive although postponement it is still in place. In 2000, it was decided that all existing light fittings with PCB ballast capacitors should be removed by 1 January 2005. But because the SFT (Norwegian Pollution control authority) feared that there would be a flood of applications for postponement, the regulation was amended just before the turn of the year. As a result, property owners now have three more years (until 2008) to remove this environmental toxin from their premises, assuming that they have conducted a survey and developed a plan to phase out PCB.

When replacing the PCB contaminated ballasts it might be a very good idea to consider a replacement by ballast that can be controlled or are prepared for this. A significant portion of any ballast conversion program is installation cost. By installing “network ready” control devices at the same time as a new ballast, additional savings in energy, maintenance, and public safety can be achieved. The benefits of networked controls exceed the minor initial installation costs.
Adding an ANSI 709.2 based Power Line Carrier (PLC) device network to an already scheduled ballast upgrade can dramatically improve the payback on the investment as described in the telemanagement section of this report.

Other hazardous substances in Outdoor Light systems are lead used for soldering electronics. The RoHS directive states that from July 1st 2006 it is no longer allowed to use lead in soldering electronics. It is important that the equipment is RoHS compliant

Mercury

Mercury is an essential ingredient for most energy-efficient lamps. Fluorescent lamps and high intensity discharge (HID) lamps are the two most common types of lamps that utilize mercury.

Mercury is a neurotoxin. Adults, children, and developing fetuses are at risk from ingestion exposure to mercury.

Using lamps with an absolute minimum level of mercury is best for the environment and should be taken into account at all times.

3.3 Lifetime increase

Because of the temperature reduction caused by dimming and switching of the ballast when a lamp is broken the lifetime of the components inside a luminaire as well as the luminaire it self increases. Higher temperature causes extended ware of the components and reduction of the temperature helps to extend the lifetime.

Second and very important is the extension of the lifetime of the lamp. Because of the dimming circumstances present in practice do sometimes deviate considerably from the conditions under which the lamp's data, such as service life expectancy have been determined (especially current-fluctuations in the electricity grid). A combination of electronic "constant wattage" ballasts and Telemanagement ensures one that these differences are almost eliminated. In practice this will lead to a significant increase in the lamp's service life expectancy, which will reduce the maintenance costs. If standard ferromagnetic ballasts are used, and a lamp failure is detected, the system will switch of the electric current to that lamp. This prevents one from uselessly using the ignition. Continuing ignition causes over-heating which will damage both the ignition as well as the ballast.

Telemanagement helps to extend the life of luminaires, lamps as well as the ballast. An exact number for this is not yet available and has to be experienced over time.

3.4 Crime reduction

We do not know if this chapter should be part of the environmental effects of Telemanagement but we have decided it is an import effect that needs to be discussed.

People care about where they live – it matters to their quality of life. The general public expects local streets to feel safe and well-maintained to have good local facilities and services, and a sense of community and neighborliness.
This environment does not just include daylight hours but also dark time as well. In the summer, our streets are dark for about seven hours a day, while in the winter, for up to fourteen (figures for the UK). It is unacceptable to just create a safe environment during daylight.

Good efficient effective street lighting improves an area in two major ways. First, it reduces crime and the fear of crime. A Home Office study found that street lighting improvements had the potential to cut crime by 20%. The UK Home Office states that improved lighting is four times better at reducing crime than CCTV. In could be argued that the vast sums of money spent on CCTV could be spent on improving street lighting to reduce crime figures in an area.

According to recent crime surveys the following numbers are found.

	In hours of darkness
Burglaries	63%
Theft from cars	72%
Theft of cars	67%
Vandalism	65%
Robbery from Person	45%

The same Home Office study noted, “Not only does street lighting work to deter crime via an increase in surveillance and deterrence, but it also benefits the community by providing a better looking public space”. Public Street Lighting can make our streets more attractive – area beautification. Good adequate lighting can transform a desolate and forbidding street into an inviting and comfortable one. Advances in technology mean that details of buildings and trees can be picked out, and up lighters can light the pathway.

Educating Local authority lighting managers, and private contractors should be undertaken to understand the needs of pedestrians. They need to know that good lighting is particularly important for older people. Those over 45 years of age require 30% more light than those under 45 to achieve the same facial recognition.

As part of the Government’s ‘Cleaner, Safer, Greener’ program, key pedestrian routes should be audited for the effectiveness of their lighting. Pedestrians need uniformity of lighting – there’s no point in lighting a bus stop if pedestrians have to walk through pools of darkness to get there. Some authorities are aware of this and are making proposals to address this issue.

4. Legislation

In this chapter we have summarized the known legislation that exists with regards to street lighting. It is hard to find all the legislation that exists but with the help of CIE 4-44 we will get a better understanding of the legislation that exists and how it should be changed to accommodate modern technology in Outdoor Lighting and Telemanagement, The following directives impact the Street Lighting industry.

Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council

Summary
Energy-using products (EuP's) account for a huge consumption of natural resources and energy in the Community.

The directive's aims are to optimize the environmental performance of products, while maintaining their functional qualities, to achieve a sustainable development and a continuous improvement in the overall environmental impact. To reduce the environmental impact of products across the whole of their life cycle is the core of this directive.

Improving the energy efficiency of products contributes to the security of the energy supply, which is a precondition of sound economic activity and therefore of sustainable development.

Action should be taken during the design phase of EuPs since it appears that the pollution cause during a product's life cycle is determined at that stage, and most of the costs involved are committed then

While the best-performing products or technologies available on the market, including on international markets, should be taken as reference, the level of ecodesign requirements should be established on the basis of technical, economic and environmental analysis.

The directive shall be brought into force 11 August 2007.

Directive 2000/55/EC of the European Parliament and of the Council of 18 September 2000 on energy efficiency requirements for ballasts for fluorescent lighting

Summary
This Directive aims at reducing energy consumption for ballasts for **fluorescent** lighting by moving gradually away from the less efficient ballasts, and towards the more efficient ballasts which may also offer extensive energy-saving features.

Article 2
1. Member States shall take all necessary measures to ensure that, during a first phase, ballasts may be placed on the market, either as a single component or incorporated in luminaires, only if the power consumption of the ballast in question is less than, or equal to, the maximum input power of ballast-lamp circuits as defined in Annexes I, II and III for each ballast category.
In the interest of international trade, international standards should be used wherever appropriate. The electricity consumption of a ballast is defined by the European

Committee for Electro technical Standardization Standard EN 50294 of December 1998, which is based on international standards.

Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment

Summary
The aim of this Directive is to bring about a reduction in the use of hazardous substances in WEEE. It will require manufacturers of electronic goods to eliminate the use of the following hazardous substances in new electrical and electronic equipment:
Lead: hexavalent
Mercury: polybrominated bupheryls (PCBS)
Calcium: polybrominated bipherylethers (PBDE)
This must be in place by July 2006.

Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)

Summary
This Directive arises to prevent and minimize the amount of WEEE produced and to maximize the amount that is reused, recycled and recovered. In fact companies that are affected will have to meet recycling targets of up to 80% of the product weight of individual appliances.

The main points of the Directive are:
Establishment of a separate collection network for WEEE – a nation-wide network is Bring Centres where households can deliver WEEE free of charge.
Financing of costs of collection, treatment, recovery and environmentally sound disposal of WEEE is to be provided for by the producers – this can be done collectively (similar to Repak scheme) or individually.
All facilities involved in the treatment WEEE must be subject to permits issued by state regulatory bodies.
The Directive must be transposed by August 2004 and member states have until August 2005 to introduce take back systems of all electrical and electronic equipment.

The overall objective of these two Directives (2002/95/EC and 2002/96/EC) is: Reduction in amount of WEEE being disposed on Landfill. Increase in the amount of WEEE being recycled. Reduction in the harmfulness of WEEE. Conservation of resources.

Commission Directive 98/101/EC of 22 December 1998 adapting to technical progress Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances (Text with EEA relevance)

Summary
The Department of the Environment, being a department designated for the purposes of section of the European Communities Act 1972 in relation to measures relating to batteries and accumulators containing dangerous substances. The directives limited the amount of cadmium, led and other substances used on batteries.

EN 50294 :1998 Measurement Method of Total Input Power of Ballast – Lamp.

Summary
With a view to achieving a third phase in energy efficiency improvement, the Commission shall then, in consultation with the interested parties, present proposals, if appropriate, regarding further improvement in energy efficiency of ballasts. The maximum input power of ballast-lamp circuits and the date of its entry into force shall be based on levels which can be economically and technically justified in the light of the circumstances at the time. Any other measure judged appropriate to improve the inherent energy efficiency of ballasts and to encourage the use of energy-saving lighting controls systems should be considered.

EU Directive 2002/95/EC Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment.

Summary
The purpose of this Directive is to approximate the laws of the Member States on the restrictions of the use of hazardous substances in electrical and electronic equipment and to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment.

EU Directive 2002/96/EC Waste Electrical and Electronic Equipment

Summary
The purpose of this Directive is, as a first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment, e.g. producers, distributors and consumers and in particular those operators directly involved in the treatment of waste electrical and electronic equipment.

5. Market Blueprint

The street light market like any other market consists of three basic entities that interact to find common solutions to problems in outdoor lighting. The three basic entities are the providers of equipment and services on the offering side, the private and governmental users on the demand side and third the group of influencers in associations and other working structures. The scope of this part of the document is to give an overview and insight in the offering side of the Outdoor Lighting market in a dynamic outdoor lighting system. The current situation is described as well as the changes that can be expected by the implementation of E-street systems.

Influencers Celma, CIE TC 4-44 CENELEC right light CEEE

5.1 Equipment and service providers

On the offering side we see that the market is divided in equipment and service providers that all provide parts of the solutions that complement each other to a full working Dynamic Street System. In all cases service providers use the equipment from multiple vendors to build a complete solution. No manufacturer in the industry that we know of today delivers a total solution except for Philips and SELC. The key players in the market are roughly connected to the key components of a dynamic outdoor lighting system.

Apart from the pole a dynamic outdoor lighting system consists of:

- Luminaires that hold the fitting the lamp and in some cases the electronics
- The lighting electronics or ballasts that keep the lamps burning
- The lamp manufacturers
- The controls that drive and switch the ballasts and the network between the controls electronics and segment controllers in the power supply cabinet
- The segment controllers in the power supply cabinet that handle and manage a segment of outdoor lights
- The wide area network that provides the communications between de segment controllers and the back office or central control system
- The central control system that allows for the management of all poles
- The existing IT infrastructure that every company has that needs information from the street light system

To get all of this to function as a logical system in almost all cases end-users ask consultants to help them define and specify the system that suits their needs. Often times these consultants also play a crucial role in the whole procurement and installation process. Even in the operational phase they monitor performance and advice for improvement.

Because of the complexity of the system and the use of IT technology we see that apart from the physical installation there is a new group of companies evolving into this market that we call “IT integrators” that approach the systems from the networking and IT part of the world.

5.1.1 Luminaire manufacturers

There is a fast plethora of luminaire manufacturers. Hundreds of companies make luminaires for various applications in Outdoor Lighting. Depending on the application it is often possible to find a luminaires manufacturer specializing in a certain field:

- heavy industry
- train stations
- tunnel lighting
- parking
- harbor
- signaling
- sports facilities
- parking lots
- parks
- airports
- railway crossings

Looking at “regular” street lighting luminaires manufacturers that operate on a European scale there are four companies dominating this market. Thorn, Schreder, Philips and Siteco claim they produce more than 80% of all luminaires use in street lighting in Europe. In every country there are one or two manufacturers that have a significant local market share but do not work on a European scale.

Luminaires manufacturers are typically mechanical engineering companies. They specialize in molding, folding, and assembling non electronic equipment. The ballast and lamps are bought from different vendors usually on end user specification. The luminaires manufacturers normally use a wholesale channel or direct sales teams per country to approach end-users.

Telemanagement, networking and electronics are normally not part of the luminaires manufacturer’s scope of delivery and they do not have the sales channel to sell it. Philips forms the exception to the rule since they employ their own controls department focusing on telemanagement solutions for indoor and outdoor. In their normal market approach to telemanagement there is certain reluctance since it could slow down the selling process and requires specific knowledge. Interestingly enough the last few years a shift can be seen towards a more open focus towards telemanagement.

5.1.2 Lighting Electronics Manufacturers

The electronics that regulate the power to the lamp and earlier in this report referred to as ballast are produced by the Lighting Electronics manufacturers. Also here there are numerous larger and smaller companies active in the market of building these electronics. Philips, Zumtobel, MagnaTek and Siemens/Osram are the key European players in this market. Also here there are various local players that often produce very innovative products or high quality products for special purposes. Selc is a good example of such a company.

The use of fluorescent light is seen more and more in city lighting applications. However the main focus for street light today is on the HID side. Basically ballast manufacturers produce two types of ballasts:

- Magnetic HID ballasts for mercury, metal halide and high and low pressure sodium lamps.

- Electronic HID ballasts bring significant performance enhancements to every aspect of HID lighting systems, with greater energy efficiency, more consistent lamp color and maximized lumen maintenance and lamp life.

All ballast manufacturers produce both types of ballasts. There are various dimming ballasts but roughly there are two categories. The self dimming ballast is one that can be set once and then at fixed (moving) times it dims and switches itself. Second there are the controllable ballasts that expect an external signal to switch or set a dim level as described in the telemanagement section of this report.

The ballast manufacturers that have telemanagement systems all produce a separate box that controls their ballast or rely on third parties to do that. The communications between the luminaries and the segment controller is not one of their competence areas and they all buy networking chips or ready made solutions from third parties. Today Powerline communication is becoming the leading edge technology to establish this part of the network although there are some manufacturers working with RF solutions. LonWorks today is the most reliable and widely use Powerline technology with over 30 million installed nodes. It is also the only formally standardized technology under ANSI (ANSI 709.2).

Ballast manufacturers do not have the channel to build and support complete solutions so they stop by offering components to the luminaires manufacturers.

5.1.3 Lamp Manufacturers

The lamp manufacturers that dominate the market are Philips and Osram in Europe. They produce all sorts of HID and fluorescent lamps that are used on Outdoor Lighting. Lamp manufacturers have a vested interest in making their lamps more energy efficient. Although in the end it is not in their interest to make lamps that last longer when dimmed they are more and more trying to anticipate on this development.

The lamp manufacturer that is most innovative in bringing a lamp that works well in a dimming environment in combination with controllable ballasts has the best cards for telemanagement solution. A key point here is the warranty given by these manufacturers on the lamp once it is dimmed.

Today there are no lamp manufacturers apart from Philips in Europe that have telemanagement systems available It is not their business to produce electronics and software.

5.2 The Controls and networking market

The controls that drive the ballasts in a telemanagement system have been briefly touched on in the ballast section. Today there are two basic ways to communicate between luminaires and the power supply cabinet where the segment controller is build in PLC (or power line communications) and RF (or radio frequency).

The use of RF is in some instances implemented but with limited success. The huge amount (growing fast) of cellular phones, hotspots and wifi routers and the fact that due to regulation RF is more or less bound to use the same frequencies makes it a challenge to build a working RF solution. Therefore it will take time for the producers of RF components and equipment to become a player in the outdoor lighting market. The common way to communicate in Street Lighting is by using the existing power cables between the luminaire and the power supply cabinet. The way this Powerline communications is done is by using transceivers (little modems) that put the signal

on the Powerline. There are several vendors of this type of technology known and they are all trying to enter this market. Echelon builds components for the ANSI 709.2 standard Powerline communication and with close to 30 million units installed in the field is the most experienced player in this market today.

The key question is what does one need to look for in a power line communication solution and how to choose the solution provider? In the case of power line transceivers, a side-by-side analysis of product specifications may not yield much information about their reliability. Two transceivers with the exact same specifications may have completely different performance characteristics. The only meaningful and effective method of evaluating a power line transceiver is by actually testing its performance in the target environment. Therefore it is important to have background on Powerline communication.

Nevertheless, there are a few key characteristics that one should look for:

1. Total number of components required for a complete communication device and the total cost associated with it. One must also factor in the need for external microcontrollers, memory, filters, or amplifiers. The cost of implementing the appropriate power supply is also a very important factor to take into account when evaluating various power line solutions.
2. The frequency spectrum it uses for communication and its compliance with regulations. This is particularly important to ensure a common networking platform that you could develop and implement in products you ship worldwide. Europe has very stringent regulations in place for power line communications, while other countries in North America, Asia, Africa and Australia are pursuing similar restrictions. *Note*: In Europe, power line signaling must be confined to the 9kHz - 148.5kHz frequency range. This spectrum is further divided in to "bands" and allocated for specific applications, as follows:
   · A-band: 9-95 kHz for electricity suppliers
   · B-band: 95-125 kHz for consumer use without protocols
   · C-band: 125-140 kHz for consumer use with the CENELEC protocol
   · D-band: 140-148.5 kHz for consumer use without protocols
   · Above 148.5 kHz: power line communications prohibited

   Using the C-band (with the CENELEC protocol) for communication ensures that only one device communicates at a time thereby minimizing collisions and improving communication reliability. The B and D-bands, although legal for communication, are more prone to collisions and interference from other solutions operating in this band.

   These bands are more suitable as alternate / secondary communication bands that may be used when the C-band is blocked by noise.
   The CENELEC protocol already implemented in Echelon's power line transceivers, eliminating the need for users to develop the complex timing and access algorithms mandated under CENELEC EN50065-1. The most stable solution at this moment is ANSI 709.2 (LonWorks) Powerline communications.

3. Communication performance in the presence of the "noisy" appliances such as low-voltage halogen lamps, computers, printers, fax machines, hairdryers, etcetera. Note that some television sets induce very high levels of signal distortion that could make it impossible for some receivers to decode the transmitted signal.

4. Requirement for "conditioning circuitry" or other wiring modifications that would require the services of a professional electrician and therefore add costs. This includes:
   -Phase couplers required by some solutions to ensure communication between sockets on different phases in a home with multiple phases.
   -Wiring modifications to support "switched-leg" circuits. A "switched-leg" circuit is a common wiring architecture used to wire lamp switches in many parts of the world including the US, Australia, New Zealand, etcetera.
5. Availability of easy-to-use tools for testing the performance of the transceiver in the target environment prior to investing in any development effort.
6. Availability of comprehensive support documentation that describes in detail every stage of the design-in process including recommendations on system architecture, power supplies, and coupling circuit design.
7. The types of applications and the number of actual deployments (not pilot projects) in the field using the technology.

So in summary there are two basic technologies that are used in PLC. Spread spectrum and narrow band noise filtering. With the current CENELEC rules a regulations it is hard to use the spread spectrum technology reliably in such a way that it is also compliant with the CENELEC. The reason being that CENELEC only allows for limited “spread”. The ANSI 709.2 narrow band solution from Echelon today is allowed in all parts of the world and works within the European CENELEC EN50065-1standard.

5.3 WAN providers

The second part of the network is the connection between the segment controller and the central management system. The protocol of choice for this part of the communications is IP.

For this part of the communication it is possible to use:

- ADSL (broadband internet connections) over fixed lines or wireless
- POTS/ISDN (analog or digital telephone lines with regular modems)
- GSM/GPRS/UMTS

ADSL provides a fast way to communicate with relatively easy installation. The down side is that it requires the infrastructure to be present either in cabling or in wireless form. In many instances GPRS is the technology of choice for the WAN communication when there is no wire available.

This group of market players is relatively new in the market of Street Light and they have limited experience today. The good news is that they have a lot of experience in providing service for M2M communications in general and that is actually identical to street light.

Service Providers are locked in a highly competitive battle for IP services revenue, with enterprises demanding increasingly stringent Service Level Agreements (SLAs) that are specifically needed in Outdoor Light applications. Yet, while production IP services have matured, operations groups still struggle to achieve the level of predictable reliability expected by customers who depend on IP service offerings for their mission-critical WAN infrastructure. This is the reason that it is very important that the telemanagement system is distributed and can operate on a per segment basis.

New solutions are underway but it will take time to get these implemented.

5.4 IT companies

It goes without saying that whenever there are computers and software involved like at the central management level for telemanagement there are IT companies that play an important role.

Today there are three types of companies interesting to the Outdoor Lighting Market:

- Network integrators
- Software developers
- IT integrators

In the following there is a brief description of these market parties.

Network Integrators
These companies usually know a lot about device networking and the implementation and commissioning of the automation part of the outdoor lighting system on the street side as well as on the WAN side.

The implementation of an outdoor lighting system requires planning both for the lighting and for the network part of the system. When Powerline communication is deployed a key success factor for the Telemanagement system is the communication between the luminaire and the segment controller. Powerline analysis and network design are very important is this phase.

Network Integrators have the skills necessary to specify and implement control systems based on the technology used. These integrators have also made Open Systems a fundamental part of their delivery strategy and provide proven solutions that incorporate the best breed of products.

The WAN communication part is also important to look for as a skill set for these companies. Load balancing in the network as well as the whole WAN design and network management is important to the success of the system.

Software developers
Telemanagement systems require software on the Outdoor Luminaire Controller level on the segment controller level (firmware) as well as on the PC level. The key in finding the right software partners is to see if open technologies are used for their software. IP SOAP/XML and SQL are all well known abbreviations in this market.

In many cases the smaller more innovative software companies start development for software to be used in new markets. Over time when the market grows the larger players start to build software for Telemanagement as well.
Due to the fast development in the technologies used for IP based applications it is hardly ever seen that a large traditional player in the market will develop their own software.

System integrators
When it comes to integrating existing enterprise applications like billing, work order management and maintenance systems with the outdoor lighting system usually a systems integrator is involved.

In general these companies competences are in the areas of systems design, database design and customer software development. Because this type of

integration affects the primary business processes often times large corporations are doing this work.

5.5 Consultants

To be able to design and implement a full scale telemanagement system it is advisable to ask for the help of a consultant. The consultant needs to be organized in such a way they can ensure that there are close ties between experts working within the different technical fields. Because of the complexity and the diversity of a telemanagement system and the many disciplines it touches as described above this is not an easy task.

Larger consulting companies usually have such a structure in place.

5.6 Service providers

The management, operation and maintenance of the outdoor lighting system is outsourced to special companies in many instances. In a number of cases these companies are part of electrical utilities but there are examples of private companies that do this as well.

The public owners of street lighting systems have the duty to keep the systems in order to ensure road safety and to fulfil the other functions of public lighting. The lack of public budget has led to a stagnation of investment in energy efficiency of the public street lighting. Now there is a critical situation with regard to high operating costs and large refurbishment necessities without public funding possibilities.

There is a “drive” towards cost reductions and outsourcing of these services and such Public-Private-Partnership (PPP) models like Contracting and especially Performance Contracting can be successful. The number of service providers offering these contracting options is growing fast.

A short study is available “Status quo on Street Lighting Contracting in Europe (Draft of the short study)" from Berlin Energy Agency.

5.7 Influencers

A in any market there is large number of influences in this market as well. It is impossible to list them all but some key players need to be mentioned.

Apart from many local bodies and organizations some organizations on a European level influence this market.

International Commission on Illumination CIE
As its name implies, the International Commission on Illumination - abbreviated as CIE from its French title Commission Internationale de l'Eclairage - is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the science and art of lighting.

The CIE is a technical, scientific and cultural, non-profit autonomous organization. It has grown out of the interests of individuals working in illumination.

Since its inception 90 years ago, the CIE has become a professional organization

and has been accepted as representing the best authority on the subject and as such is recognized by ISO as an international standardization body.

Within the CIE the work group TC 4-44 *Management and Maintenance of Road Lighting* has the task to revise Publication CIE 115-1995 in such a way that lighting performance requirements may vary depending on actual status of environmental and traffic conditions. The CIE 115-1995 RECOMMENDATIONS FOR THE LIGHTING OF ROADS FOR MOTOR AND PEDESTRIAN TRAFFIC is an earlier document about road lighting,

CELMA
CELMA is a Federation established for an unlimited period, representing 16 National Manufacturers Associations for Luminaires and Electro technical Components for Luminaires. CELMA members' Associations are representing some 1150 companies in the Luminaires and Electro technical Components for Luminaires industries in 11 European countries. These 1150 producers, which include a majority of small and medium-sized companies, directly employ more than 52.000 people and generate around 10 billion Euro annually.

CELMA acts as a Body of contact, co-ordination, representation and assistance for the National Associations, Federations and Organizations in the EU manufacturing of Luminaires and electro technical components for the Luminaires Industry. The scope and objectives of CELMA are to study all matters of common interest, with particular emphasis on their scientific, educational, legal and institutional aspects and provides policies such as contact, co-ordination, representation and assistance for European and national associations, federations and organizations in the EU involved in the manufacture of Luminaires and electro technical components for the Luminaires Industry.

Intelligent Energy – Europe (IEE)
IEE is a main means of converting EU policy for smart energy use and more renewables into action on the ground, addressing today's energy challenges and promoting business opportunities and new technologies.

IEE supports European projects, one-off events and the setting up of local/regional energy agencies with a total budget of €250 million, covering up to 50% of the costs.

The program currently supports more than 200 international projects, 30+ local/regional energy management agencies, and almost 40 European events in the areas of

- new and renewable energy sources
- energy efficiency, notably in buildings and industry
- energy aspects of transport
- co-operation with developing countries

The E-street initiative is one o the project support by the IEE. This working group will have a lot of impact on the deployment of Telemanagement because it will document and research many questions that exist about this way of saving energy today.

6 Barriers

Among decision-makers, administrators, and street light owners many questions are raised concerning intelligent street lighting, and in general some people are skeptical to the new technology. Firs the lack of knowledge about the technologies used is a barrier and secondly the investment cost and return on investment are hot items for decision makers.

The operation budget does not have room for large investment in new technology and therefore the lack of financial instruments is a barrier for this new technology. By documenting that the total cost for the system including investment-, running- and maintenance costs over the lifetime is considerable lower with the new technology one may overcome the economic barriers. Within the E-street initiative WP 6 is working on this part of the solution.

The best way to overcome barriers is to provide information about the technology through different communication channels. I.e. we need to give presentations at international conferences or congresses where the decision-makers, stakeholders etc have the opportunity to ask questions and get correct answers straight away or by being a part of an EU project like E-street.

There are many different barriers, and the barriers vary from country to country. The list below present common barriers that have been identified in this work package:

- Lack of information to end users, decision makers and consultants
- High investment cost
- No financial instruments
- Political focus on other projects
- Old installations are still running
- Maintenance, have already a good maintenance system
- Technology price, and function time
- Complexity of the system and conservatism in the marked
- Ownership of the street lights
- Tenders
- Measurement of the energy consumption
- Small end users are purchasing through the normal cannel/system and are not being offered the total system
- Lack of standardization

6.1 Lack of information to end users, decision makers and consultants

With either lack of knowledge or poor knowledge it is impossible for decision-makers, administrators or consultants to make the right decision. Lack of knowledge can lead to skepticism. The conclusion is that accurate information with documentation from research activity is the best way to convince the decision-makers.

The vendors of these systems need to take responsibility and start to provide trustworthy material on the subject based on research and hard numbers.

6.2 Investment cost

Investment cost is a barrier when 10.000 to 100.000 luminaries are being retrofitted. It is important that accurate calculation of the profitability is available. In this EU project Investitionsbank Schleswig-Holstein (IB) from Germany are working on the calculation methods for profitability and the calculations will show that all depends on the length of the investment period.

The financial situation can be positively influenced by using the replacement or re-lamping situation or the normal replacement of equipment in combination with the implementation of Telemanagement.

6.3 No financial instruments

Another financial barrier is lack of financial instruments. IB has the expertise when it comes to financial instruments/investment models. They are building a special solution for administrators who consider investing in intelligent street lighting.

Calculation and analysis from the project in Oslo shows that even with seven percent interest cost and a lifetime of 12 years for the electronic, the project is profitable.

6.4 Political focus on project

Retrofitting of existing street light to intelligent lighting is at risk not getting the interest it ought to get. The reason can be low visibility of the project compared to rehabilitation/ construction of roads and squares. It is of great importance to highlight the environmental aspects in these projects such as, energy savings, reduction in light pollution, elimination/disposal of PCB and reduction in energy- and maintenance costs in a full scale installation. This will increase the political focus on these type of projects.

6.5 Old installations are still running

Many installations around the world are still running satisfactory hence it can be difficult to persuade that retrofitting the installations are profitable. Arguments that can be used for retrofitting the installations are new EU directives concerning prohibition against mechanical ballast (2009) and mercury (2010), and disposal of PCBs (Directive 96/59/EC) (2012). Further most of the street light installations around the world do not have energy metering, and the introduction of this technology will result in a greater focus on energy use and energy saving. This new technology will bring focus on a new energy efficiency arena that so far has not been recognized.

6.6 Maintenance

Many street light owners have good maintenance routines. These are routines that are followed up in the traditional way and these systems have been working for many years. These systems and routines have a high consumption of person-hours and are often not based on computer systems and web technology. Reduction of person-hours can in some countries be a barrier for the introduction of the new system that causes a reduction in person hours. This system will decrease running and maintenance cost, contribute to better and faster service to the general public and fillings of incidents and documentation of errors can be used in possible claim against suppliers of equipment.

Claims to the city because of accidents due to light deficiencies will be reduced.

6.7 Technology and price as a function of time

The lifetime of new electronic equipment can be shorter than the products used today. It is more the perception than it is reality but many decision makers believe electronics have a shorter lifetime than required. Interestingly enough many of them watch 15 years old television sets every day. Still the price and the lifecycle of the technology is a barrier. The price is decreasing fast and that is mainly supported by

the results of the project in Oslo. During the three purchases the cost decrease in the tender was approximately 50 %. This is not a unique situation as in general electronic equipment has a considerable reduction in the price during a relatively short time period after initial introduction. Therefore a market expansion will lead to lower the prices while the technology develops. When it comes to the lifecycle of electronic equipment used in intelligent street lighting it is difficult to predict. The equipment is quite new and has not been in use very long. Skepticism to how the electronics will cope with outdoor environment in relatively simple constructions as fittings and luminaires are related to questions concerning variations in temperature and humidity. For the project in Norway a lifetime of 12 years for the electronics has been used to calculate the ROI.

6.8 Complexity of the system and conservatism in the marked

Intelligent street lighting can in many ways seem complex. Lack of knowledge about the functions and components of the system can lead to this opinion. The system based on Powerline communication technology is brilliant from the street light owner's point of view, because he does not have to interfere with the existing infrastructure. It is not necessary to dig in roads or pavement because the technique is being installed on the existing poles and in the power supply cabinet. The control of the system is through a computer system. Each luminaire has its own unique identity, a chip, which makes it possible to control and adjust the effect on each luminaire individually. This might seem complicated for some decision-makers and therefore some are waiting. For this reason it is important to document the efficiency, financial aspects and the savings that come with this new technology. The documentation is preferably based on research from universities and recognized experts in the streetlight market. Documenting the advantages in combination with the introduction of new standards and guidelines will help decision makers to come to a decision on this technology.

6.9 Ownership of the street lights

Ownership can be seen as a barrier. When it comes to street lighting there are numbers of different ownerships forms around the world. Here follows some examples.

1. Municipalities can own the power plant as well as the streetlight
2. The power plant has been separated into a municipal company and are administrated/run on business terms/conditions and also owns the streetlight
3. Both the power plant and the streetlight have been sold to a service provider
4. The power plant is sold, but the streetlight is still owned by the municipality etc.

None of the mentioned ownership above should act as a barrier. The question is more who will carry the investment. In principle the one who makes the investment should also get the profit and administer the project. From the above it becomes clear that the ownership should not be a big issue. More important is who will carry the investment costs.

6.10 Tenders

There is huge effort attached to the preparation of a tender because of the fact that the system needs expertise from different fields. It is essential that one chooses an open solution to not get locked in by a vendor. Once demand for these systems in the market increases this will gradually disappear.

6.11 Measurement of the energy consumption

It is important that the company paying for the energy gets a benefit from the savings realized by the new system. When introducing intelligent street lighting it is essential to assure that the right to purchase electricity in the free market (Europe) does not become not limited to several owners in the same power grid. Further one must make sure that special duties are not being introduced under pretext of new technology. Today we are missing/lacking a way to measure the energy use in the luminaire. This is a significant barrier we need to overcome.

6.12 Lack of standardization

Updated international and European standards of dimmable streetlight may lead to increase the energy saving potential and hence increase the profit of new and retrofitted intelligent streetlight installations. The standardization of the technology used is not a real problem because suitable standards exist.

The problem is in the legislation and standardization that does not allows for dimming light.

6.13 Conclusion on barriers

As in any new and existing market there are some barriers we need to overcome. Most of the barriers we see are related to the lack of information, documented result and financial instruments.

The E-street initiative will help enormously to overcome many of the mentioned barriers and is therefore an essential tool in saving energy in Europe.