

Open Streetlight Control System for Smarter Cities

Market, Challenges, Solutions and Next Steps

A profitable and strategic opportunity for cities, ESCOs and streetlight maintenance operators

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Streetlights: valuable but expensive assets for Cities

Streetlights are among a city's strategic assets: providing safe roads, inviting public areas, and enhanced security in homes, businesses, and city centers. However they're usually very costly to operate, and they use in average 40% of a city's electricity spending. As the cost of electricity continues to rise and as wasting energy is a growing concern for public and authorities, it's becoming crucial that municipalities, highway companies and other streetlight owners deploy control systems to dim the lights at the right light level at the right time, to automatically identify lamp and electrical failures and enable real time control. Cities that create such controlled streetlight networks can not only save up to 50% on energy and drastically enhance the maintenance service and safety in the street, but also leverage the streetlight grid as the backbone of other smart city applications.



The cost of operating a streetlight network

The cost of operating a streetlight network is usually split into:

- **Electricity costs:** table 1 provides the average price of electricity per kWh for citizens in the European countries and in China. The streetlight network is a city's primary consumer of electricity, representing 40% of a city's electricity spending. The number of streetlights, the wattage of the lamps and its ballast/driver, and the number of hours during which the lamp is operating (average 4,000 hours per year) all contribute to the total electricity cost.

Example: The annual electricity costs to illuminate a city of 100,000 inhabitants is more than 1,3 M\$ in most European countries.

- **Maintenance costs:** night patrols to visually identify failed lamps, replacing failed lamps, cleaning optics and maintaining the integrity and security on the electrical grid require crews of streetlight specialists and service trucks. More than 80% of the streetlights are equipped with high pressure sodium lamps with a lifetime under 3,5 years, i.e. 14.000 burning hours. The maintenance costs per light point varies enormously from one country to another, depending on cost average salaries and service level agreements. In Europe, the average cost of maintenance is estimated to be in the range of 50 USD per light point per year.

Example: The annual maintenance budget for a city of 100,000 inhabitants is more than 0,7 M\$ in most European countries.

Rank	Country	Average US\$ per kWh
1	Denmark	\$0.2708
2	Germany	\$0.2438
3	Belgium	\$0.1974
4	Sweden	\$0.1958
5	Austria	\$0.193
6	Italy	\$0.1919
7	Ireland	\$0.1875
8	Spain	\$0.1851
9	Luxemburg	\$0.1747
10	Netherland	\$0.1696
11	Portugal	\$0.1666
12	China (Guangdong Province)	\$0.1505
13	UK	\$0.1449
14	Finland	\$0.137
15	France	\$0.1289
16	Greece	\$0.1211

Table 1: Average price of electricity (source: IFRI 2011)

Streetlights cause carbon dioxide (CO²) emissions

Besides being expensive, streetlights contribute to air pollution. Producing one kWh of electricity with a nuclear plant generates about 100 grams of CO², while producing one kWh of electricity from a coal plant produces up to 1 kg of CO². The production of electricity needed to power street lighting systems adds to carbon dioxide emissions (CO² is the principal “greenhouse gas”) and nuclear dust. Table 2, below, provides an estimate of electricity use and the associated CO² emissions for some countries.

Country	Estimated number of streetlights	Estimated number of kWh per year	Estimated annual electricity cost for streetlights	Estimated annual CO ² emissions due to streetlights
U.S.	> 68 million	> 30 billion	> \$2 billion	> 15 million tons
European Union	> 90 million	> 52 billion	> \$4.7 billion	> 20 million tons
U.K.	7.7 million	> 4.5 billion	> \$420 million	> 2 million tons
France	8.7 million	5.2 billion	> \$350 million	> 600,000 tons
Brazil	14 million	> 10.1 billion	> \$1.3 billion	> 2,6 million tons

Table 2: Estimate of electricity use and associated CO² emissions

To get an idea of the CO² emissions and electricity budget of your city's streetlight network:

- Yearly CO² emissions for street lighting = (42 x N) kg of CO², where N is the number of inhabitants in your city.

*Example: 252 kg of CO² per streetlight in average in Europe
4200 tons of CO² per year for a city with 100.000 inhabitants*

- Yearly electricity budget for street lighting = (13 x N) kUS\$, where N is the number of inhabitants in your city.

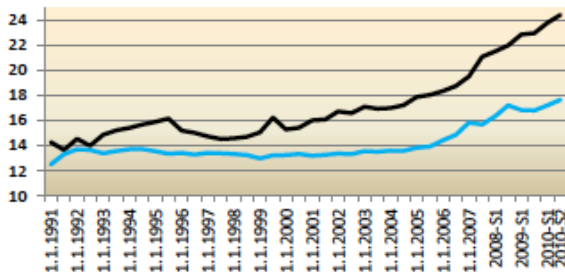
Example: 1.3 MUS\$ per year for a city with 100.000 inhabitants

The Challenge for Cities

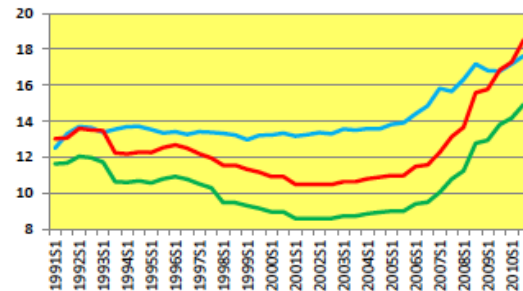
One challenge facing cities involves increasing their attractiveness for companies and people, in a fast changing world. Providing a safe and secure environment, developing innovative services to citizens, contributing to a greener city and enhancing budget efficiency are amongst key priorities for many cities.

As demonstrated by market studies (e.g. McKinsey - Lighting the way: perspectives on the global lighting market), more and more cities understand that their streetlight network may play a strategic role in helping them overcome these challenges, particularly to:

- Increase street safety: reduced lamp downtime and enhanced street visibility is directly linked to driver and pedestrian safety and comfort. Studies show how improved street lighting reduces crime and improve the feeling of being in a secured place.
- Improve maintenance processes: automatic lamp and electrical failure identification, monitoring streetlight cabinet and light points contribute to maintenance budget reductions, while improving lighting service quality.
- Reduce energy consumption and communicate on associated CO₂ savings 1) by deploying more energy efficient dimmable HPS and LED luminaires and 2) by dynamically adapt light levels, controlling and monitoring streetlight and streetlight switching cabinets. The rising price of electricity is, by itself, responsible for the majority of the increase in streetlight operation budgets. It's now becoming strategic and compelling for cities to implement solutions to measure, analyze and reduce electricity use, decrease maintenance costs, challenge their energy providers and contribute to the reduction of CO₂ emissions, as required by the Kyoto Protocol.

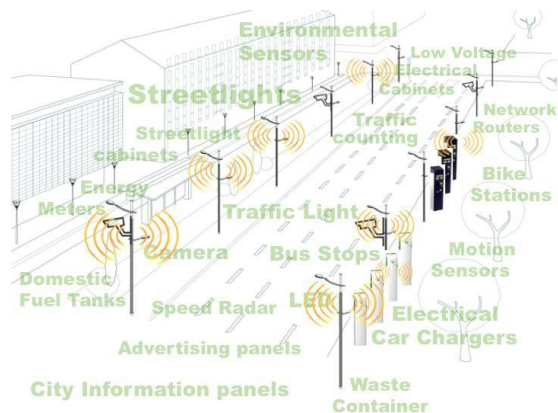


Evolution of kWh price in Germany (black) compared to Europe average (blue)



Evolution of kWh price in Spain (red) compared to Europe average (blue)

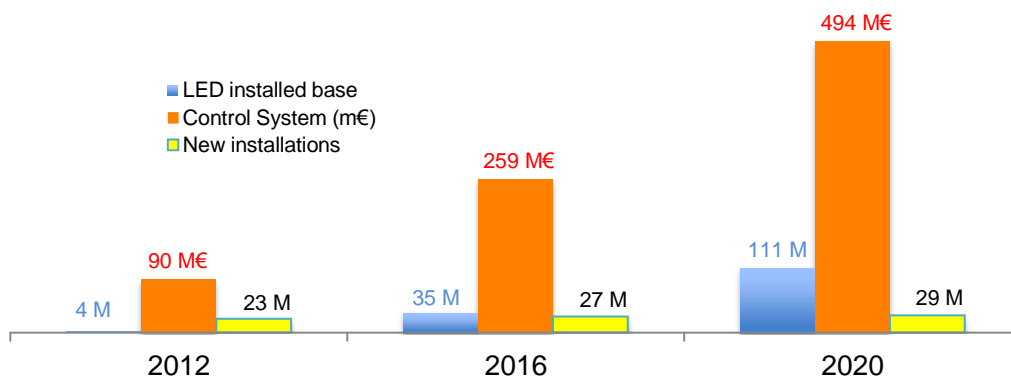
- Leverage their streetlight grid as a backbone to supply energy to smart city equipment and to monitor environmental sensors and other electrical or communication equipment rather than spending money on additional civil works to deploy additional power cables. Unlike in the USA and the UK, the entire streetlight grid is switched off during the day in European and Asian cities. Thus, these grids cannot be used to connect surveillance or traffic cameras, environmental sensors, information panels, EV charging stations, traffic lights, Wi-Fi spots, ...



Retrofitting old inefficient high pressure sodium or mercury-vapor streetlights to LED lights and equipping them with “Dynamic Streetlight Control Systems” is the solution for cities to address all these challenges as demonstrated further in this document.

“In the outdoor application, simple timers were once the only type of lighting control system used, but this is now another fast-growing area. More dynamic lighting control systems are emerging to improve the economics of investment by governments and municipalities by maximizing energy savings as well as improving the lifetime of light sources. Dynamic lighting control systems can also enhance the safety or ambience of an area by adjusting light output according to the brightness of the natural light available.”
McKinsey market study – 2012

Some cities have started to deploy LED luminaires and Dynamic Streetlight Control Systems but more will follow in the next years, as indicated in the McKinsey’s 2012 Global Lighting market study, summarized in the following drawing:



Dynamic Streetlight Control Systems is a relatively new concept for cities. Without learning more about possible solutions, features and benefits, many cities may invest in proprietary solutions that become expensive stranded assets since they can’t evolve to smart city platforms in the future.

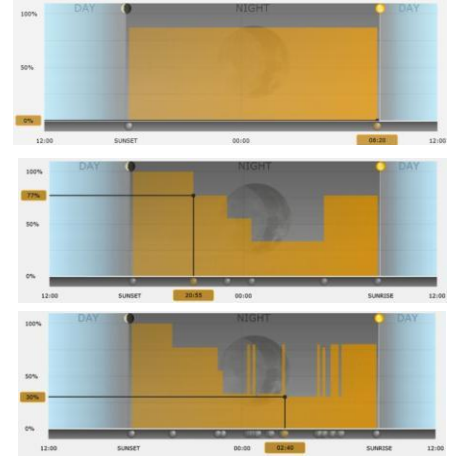
The variety of proprietary systems can make it difficult for cities to choose the best solution and, consequently, limits their ability to reduce energy and maintenance costs. Cities should not be dependent on a single vendor for such a strategic and long-life assets. To protect public investment, cities should specify open, interoperable and interchangeable solutions that are future proof and offer a better return on investment.

Solution: objectives, architecture, features

Objectives of a Dynamic Streetlight Control System

The main objectives of a Dynamic Streetlight Control System should be to:

- Reduce energy consumption
 - by switching ON/OFF at the right time
 - by dynamically adapting lighting levels at each light point to the light output required by the lighting standard, at fixed time and/or based on the activity in the area
 - by identifying energy theft on dedicated streetlight networks
 - by identifying current leakage on streetlight dedicated networks
- Reduce maintenance budgets
 - by replacing night patrols with automatic failure identification mechanisms
 - by enabling remote real-time control and monitoring to check any situation remotely rather than sending crews onsite
 - by assigning tasks based on failure reports to designated teams and by monitoring the performance
 - by identifying and transmitting to on-site teams the necessary spare parts to have on intervention, based on analytics of the failures
- Enhance safety, lighting and maintenance services
 - by identifying any failure on the network (lamp failure, segment failure, accident on a pole, cycling lamp, high/low power, high/low voltage, low power factor, etc...) as fast as possible to reduce lamp downtime
 - by identifying cable theft which is an increasing issue in many countries
 - by producing key performance indicators, reports and generating advanced alarms to anticipate any issue, identify potential problems and fix them before they become critical
 - by monitoring the lamp's burning hours to change lamps before they actually fail
- Use the streetlight network as the backbone of smart city applications
 - by using the streetlight control system as a city-wide communication network to control/monitor any sensor and other devices through the same Infrastructure
 - by keeping the power ON during the day on dedicated streetlight networks in order to power videosurveillance cameras, WiFi spots, 4G (future 5G) base stations, environmental sensors and other electrical devices, instead of investing in additional expensive power cables and civil works to power these devices.

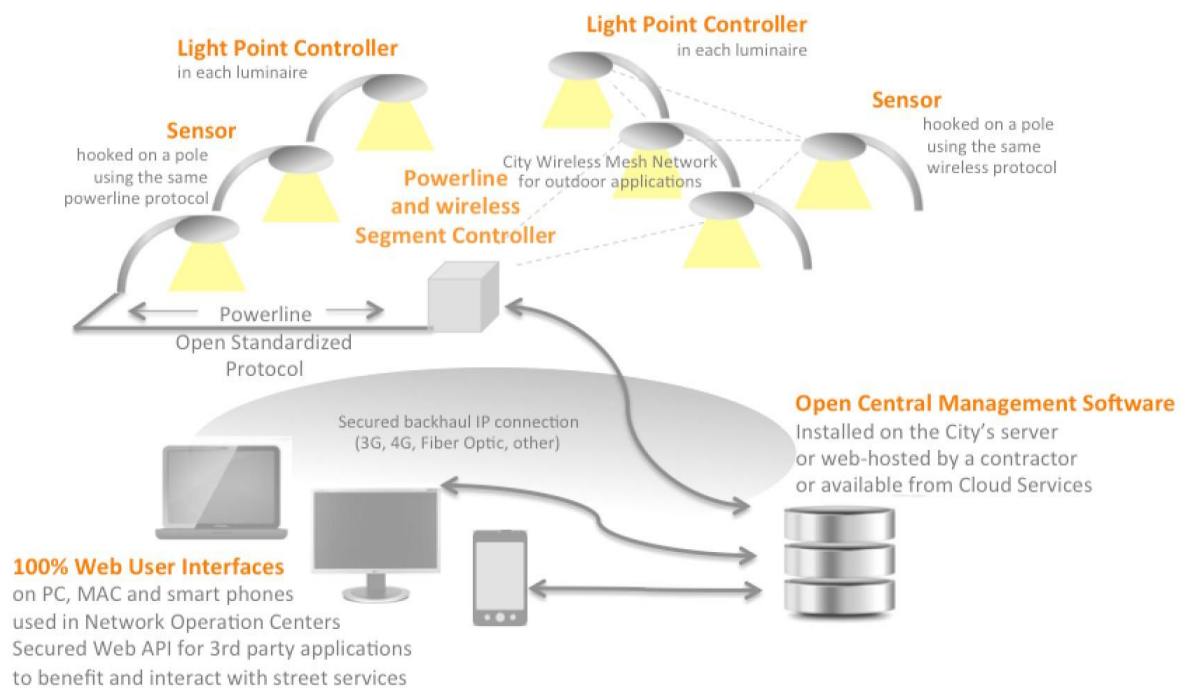


To fulfill such challenging objectives while being evolutive and future-proof, Dynamic Streetlight Control Systems must be based on open and standardized communication protocols that are:

- Proven to be scalable to support city-wide networks for streetlights, sensors, meters and other devices
- Known to address issues of large communication networks (e.g. security, dynamic routing, addressing)
- Adopted by many manufacturers to offer a wide range of possible light point controllers, gateways, segment controllers, meters, sensors, digital and analog inputs and other devices.

System architecture for Dynamic Streetlight Control

To achieve the above objectives, the recommended system architecture is based on the following key components:



Light Point Controllers – Key Requirements

Need	Requirements
Need to fit with any shape of luminaire	Light Point Controllers can be integrated either at the bottom of the pole or inside the luminaire.
Easiness of installation	Light Point Controllers should be easy for installers to install and to commission.
Low energy consumer	Light Point Controllers should consume less than 3 watts.
Operation Temperature	Light Point Controllers should support operating temperatures from -40°C to +80°C to support temperature in luminaires and/or pole base.
Switching control	Light Point Controllers should embed one or more relays to switch the light point ON/OFF through the control system.
Stepless dimming control	<p>Light Point Controllers should be capable of stepless dimming with the possibility to set the dimming level at any % (with accuracy of 1%).</p> <p>Dimming interface should be either 1-10 volts, DALI or PWM to fit with most of the LED drivers and electronic ballasts on the market.</p> <p>Dimming for electromagnetic ballast should be via voltage regulation and power factor control.</p>
Communicate using a standardized ISO protocol	Light Point Controllers should implement bi-directional communication using a standardized ISO-approved protocol that is adopted by many manufacturers of Light Point Controllers to provide interoperability with different Central Management Software solutions. It should receive and execute real time switching and dimming commands. It should accept information reading commands and it should answer such metering reading requests in real time.
Implement an internationally agreed functional profile such as the LONMARK profile	On top of using a standardized communication protocol, Light Point Controllers should implement an internationally agreed functional profile such as LONMARK Streetlight Profile, agreed and implemented by multiple competing vendors, to offer end-users with a way to interchange Light Point Controllers from various vendors.
Compatible (inter-changeable) with other Light Point Controllers from other manufacturers	By using a standardized ISO protocol, Light Point Controllers should be interchangeable with other Light Point Controllers supplied by other manufacturers.
Repeat the communication signal if necessary	Light Point Controllers should act as signal repeaters to avoid the need to install additional signal repeaters/filters/couplers, to establish automatic mesh networks and to simplify the deployment of the systems.
Detect various failures and alarms	Light Point Controllers should be able to detect driver and lamp failure, low/high mains voltage, low/high current, low power factor, high temperature for LED luminaires, cycling lamps and day burners.
Measure electrical values	Light Point Controllers should be able to measure mains voltage, current, power, power factor and temperature (for LED luminaires).
Measure cumulated energy consumption	Light Point Controllers should be able to measure and store the cumulated energy consumption in kWh.
Measure number of burning hours	Light Point Controllers should be able to measure and store the cumulated numbers of lamp burning hours.
Over the air software update	It should be possible to upgrade Light Point Controllers' embedded software via the communication network.

Segment Controllers or Gateways – Key Requirements

Need	Requirements
Dimensions and ease of installation	The dimensions of the Segment Controller should be compatible with the size of the existing streetlight cabinets in which it shall be installed. It shall be installed on a DIN RAIL to be compatible with most electrical installation standards. Wireless gateways may be installed in a different way and independent on the existing streetlight electrical cabinets.
Secured TCP/IP communication via any Ethernet media	The Segment Controller or Wireless Gateway should be able to communicate with the Central Management Software using secured TCP/IP over any Ethernet media including GPRS, 3G, 4G, WiFi, ADSL and Fiber Optic. Proprietary protocols are discouraged.
Remote configuration	The Segment Controller or Wireless Gateway should be capable of being remotely configurable through Central Management Software.
Operation Temperature	The Segment Controller or Wireless Gateway should support temperatures from -40°C to +60°C without any additional ventilation nor heating devices.
Control and monitoring of streetlight electrical cabinets for dedicated streetlight networks	The Segment Controller should provide streetlight cabinet control features including: <ul style="list-style-type: none"> • Programmable astronomical clock • Mains switch control • Open door monitoring • Segment failure identification • 3-phase metering including power, voltage, current, power factor, energy and harmonic distortion (THD) • Support modbus extensions for additional digital/analog inputs
Support open protocols that are implemented by several manufacturers	The Segment Controller or Wireless Gateway should implement and support one or more standardized ISO protocols to communicate with, control and monitor any Light Point Controller that supports the same protocol. The Segment Controller or Wireless Gateway should support Light Point Controllers from several manufacturers, excluding itself.
Autonomous control	The Segment Controller or Wireless Gateway should control the Light Point Controllers autonomously, without any connection to the Central Management Software.
Open Protocol with the Central	The Segment Controller or Wireless Gateway should be capable of communicating
Management Software	with the Central Management Software using standardized methods such as XML and HTTP messages. No proprietary protocols should be used in order to be able to provide interconnectivity and interoperability between different segment controllers and different Central Management Software Application from various competing software suppliers.
Group control and individual light point control	The Segment Controller or Wireless Gateway should provide ways to switch and dim groups of light points as well as individual Light Point Controllers.
Schedulers and calendars	The Segment Controller or Wireless Gateway should enable many types of switching/dimming schedulers for each group of Light Point Controllers. It should enable the end-user to program switching/dimming schedulers during exception days (e.g. July 4th), exceptional periods (e.g. from July 1st to August 31st) and manage the priority between standard schedulers and exception schedulers. Schedulers should not be limited to a certain number of switching/dimming steps per night. Switching and dimming commands should be set either based on fixed time, based on astronomical time (sunset/sunrise + or – a time shift) or based on sensor-based scenario.

Dynamic lighting	Switching and dimming commands should be set either based on fixed time, based on astronomical time (sunset/sunrise + or – a time shift) or based on user-configurable sensor scenario.
Push data to the Central Management Software	The Segment Controller or Wireless Gateway should collect data from the Light Point Controllers and send/push them to the Central Management Software in an unsolicited way to ensure scalability and event-based data collect.
Record historical data while no communication with Central Management Software	The Segment Controller or Wireless Gateway should keep up to one month of data on its local flash disk if no communication with the Central Management Software
Real-time clock management	The Segment Controller or Wireless Gateway should provide a way to automatically synchronize its internal real-time clock with NTP servers. It shall automatically update its real-time clock when summer/winter time shift.
Programmability	The Segment Controller or Wireless Gateway should provide ways to add additional applications in the Segment Controller or Wireless Gateway, to support new smart city applications, develop other specific features or support new protocols.

Central Management Software – Key features

Need	Specified feature
Multi-user Web Application Server	The Central Management Software should be based on an open Web Application Server. Its user interface should be 100% Web-based and accessible from any computer on the network through various types of web browsers including Microsoft Internet Explorer, Safari and Chrome.
Enterprise server and Cloud-based server	The Central Management Software should be available to be installed on the city's server as well as available, as an option, on a web-hosted server (i.e. cloud or SaaS model).
Smart phone and tablet user interfaces	User interfaces should be available for iOS, Android and Windows 8 phones and tablets.
Based on open technologies	The Central Management Software should be developed with open and standardized languages including Java, XML configuration files and SQL database. It should enable the development of additional features without the need to acquire any development software license.
Open database engine	The Central Management Software should record all the data in a centralized SQL database and should be compatible with MYSQL or PostgreSQL to avoid being obliged to purchase additional software license for database engine.
User authentication system	The Central Management Software should enable administrators to create, modify, delete users, passwords, groups and access controls. It should provide modern and efficient security features.
Support multiple types of Segment Controllers and	The Central Management Software should support most of the widely deployed powerline and wireless Control Systems, from various competing hardware suppliers.
Wireless Gateways	The Central Management Software should be able to provide interconnectivity and interoperability between solutions from different hardware manufacturers to guaranty independence between Central Management Software layer and field hardware layer.
Support multiple models of Light Point Controllers from various manufacturers	The Central Management Software should support configuration, programming, control and monitoring of many different types/models of Light Point Controllers from many competing suppliers.

Support multiple languages	The Central Management Software should support multiple languages and dictionaries shall be exportable and modifiable by the administrator of the system.
Provide map-based inventory	The Central Management Software should create any object (streetlight, streetlight cabinet, sensor, meter, etc...) and enable users to group objects per geographical zone, to move, delete and duplicate objects on the maps.
Compatible with multiple map sources	The Central Management Software should enable the end-user to select the map source of his/her choice: Microsoft Bing, Google, Nokia map, ESRI, etc...
Support multiple types of objects	The Central Management Software should support Light Points, Segment Controllers, Gateways, Sensors, Electrical Vehicle Charging Stations, Weather Stations, Energy Meters and other types of objects to provide evolution to smart city applications.
Streetlight management related features	<p>The Central Management Software should provide streetlight-specific features such as:</p> <ul style="list-style-type: none"> • Programming and commissioning schedulers • Real time control and monitoring of Light Point Controllers • Real time control and monitoring of Streetlight Cabinet • Big data and automatic data collect • Data analytics including maintenance reporting, lamp failure analysis, energy consumption reporting, energy saving calculation, complex alarm triggering and notification, lamp lifetime analysis and data history analysis.
Provide web service interface for 3 rd party software	The Central Management Software should provide HTTP REST XML web service to interface with third party software.

The key requirements listed above are issued from extracts of tenders from large cities such as Paris, Oslo, Dublin, Lyon, Jakarta and Brasov.

Analysis of the various systems available on the market

Categorizing available systems

The variety of systems available on the market can be categorized as follows :

- **Category 1: Non-managed LED luminaires:** low cost LED manufacturers provide non-controllable non-dimmable LED luminaires. While such LED luminaires save an average of 35% energy when compared to equivalent high pressure sodium lamps, most of them have not proven to provide steady light output for more than few years. While the average LED lifetime is expected to be around 50.000 hours (against 14.000 hours for high pressure sodium lamps), streetlight maintenance companies still have to clean streetlight optics every 2 or 3 years in most large polluted cities. They also need to manage the growing number of electrical failures (e.g. growing inrush current with LED luminaires, cable theft, power theft), thus not achieving the maintenance cost targets promoted by LED manufacturers.
- **Category 2: Autonomous dimmable luminaires:** (electronic ballast/driver with high pressure sodium lamps or LED lamps): autonomous dimmable luminaires are not much more expensive than non-dimmable luminaires but they consume about 25% less energy. Like Category 1 above, such systems do not address maintenance issues, nor enable cities to deploy smart city applications but they can be a first step if they provide with a way to upgrade to Dynamic Streetlight Control Systems.
- **Category 3: Streetlight cabinet control systems:** Such systems are applicable only for dedicated streetlight networks where lights are switched by a master circuit breaker in the streetlight electrical cabinet. They are not applicable to the USA and UK markets. Controlling the streetlight cabinet increases remote control over ON/OFF times and helps identify lamp failures. But most streetlight cabinet control systems are not designed to extend to individual light point control using powerline or wireless protocols, not enabling cities to reduce their energy consumption. When used in conjunction with a segment "mains voltage variator", suppliers claim to save up to 30% energy by reducing the mains voltage from 230 volts to 180 volts. It is important to note that electronic ballasts and LED drivers are not compatible with such mains voltage dimming technics, which makes mains voltage dimming obsolete on the market.
- **Category 4: Proprietary individual light point control systems:** More than 50 suppliers have developed their own proprietary protocol (powerline or wireless) to communicate between their Light Point Controllers installed in each luminaire and their Segment Controller or Wireless Gateway. Each supplier had to make significant investments to develop Light Point Controllers, reinvent protocols, security, network routing, gateways, software and tools to manage each layer of their proprietary system. By using open systems every manufacturer benefits from existing code and availability of standard components developed and tested in other markets by many market players. Proprietary systems require massive investments from the supplier and consequently result in a solution with fewer features. But more importantly, proprietary systems are only supported by a single manufacturer. Would you purchase computers that could send emails only to computer from the same brand or print to their own printer ? Would you purchase a camera that could take pictures that can only be displayed on a screen from the same manufacturer ?
- **Category 5: open individual light point and cabinet control systems:** When many manufacturers adopt a common, standardized communication protocol, making their products interoperable and interchangeable, cities have the choice between multiple products, while manufacturers have access to a larger market. Such solutions exist and can address both electrical cabinet control as well as individual light point control. In addition, since protocols are standardized, they can be used to control and monitor many other «Smart City» devices including sensors, energy meters, waste containers, water pipes, electrical vehicle stations, city information panels and more. Currently, the ISO14908 standard is adopted by more than 20 manufacturers who developed interoperable Light Point Controllers. With 20+ competing companies all using the same communication standard there are exciting new opportunities for cities and streetlight maintenance companies to implement intelligent, dynamically controlled streetlight networks.

Comparative study

	Open individual light point and cabinet control Category 5	Proprietary individual light point control Category 4	Streetlight cabinet control with/without segment voltage dimming Category 3	Autonomous dimmable luminaires Category 2	Non-dimmable LED luminaires Category 1
Some of the solution providers	Osram, Rongwen, Vossloh Schwabe, Citylone, Echelon, Amko, Thorn, Philips Starsense powerline, Apanet, Flashnet	Harvard, Telensa, Philips Starsense RF, Umpi, Roam, ...	Philips Amplight, Arelsa, Reverberi	Osram, Tridonic, Philips	Many low cost LED luminaires
Energy Savings from dimming	Up to 45%	From 30% to 45%	Up to 20%	Up to 30%	No dimming
Stepless Dimming	Yes	Not all (many are 2-step dimming)	No, even with mains voltage dimming	Only up to 5 pre-programmed dimming levels	No
ON/OFF control, scheduling and astro clock	Standard feature	Standard or optional feature	Standard or optional feature	No	No
Real time remote cabinet control and monitoring	Yes	Most of these solutions only provide light point control	Yes, but cabinet control only	No	No
Real time remote light point control and monitoring	Yes	Yes, even if some of these systems are not bi-directional	No	No	No
Automatic lamp and other failure detection	Yes	Yes	No	No	No
Alarms via Web portal / cell phone	Yes, including advanced alarms	Yes with most of them	Only for cabinet alarms	No	No
Automatic energy saving calculation	Yes	Not all	No	No	No
Increased lamp lifetime	+20%	+20%	No	+20%	No
Support constant light output	Yes	Not with most proprietary solutions	No	No	No
Support sensors and dynamic lighting	Yes	No, except AEG and COMLIGHT	No	No	No
Compatible with open Central Management Software	Yes	No, except Paradox, Silver Spring Networks and Telematics	No, except Arelsa	No	No
Smart city extensions	Yes	No, except Silver Spring Networks, Paradox and Telematics	No	No	No
Average price per light point	From \$70 to \$120	From \$70 to \$180	From \$40 to \$80	N/A	N/A
Estimated ROI	< 5 years (from 2 to 8 years depending on price of kWh and lamp wattage)	< 5 years (from 2 to 10 years depending on price of kWh and lamp wattage)	No ROI without mains voltage dimming, but then not compatible with LEDs	< 8 years	< 10 years
Feature level	9 / 10	5 / 10	3 / 10	N/A	N/A

Best practice: open individual light point and cabinet control systems

With solutions described as in “Category 5” above, cities are able to start small today with cabinet control and later install Light Point controller to benefit from energy and maintenance services. Cities are not locked-in with any particular supplier and can benefit from any new compatible product released on the market. Currently, LONMARK International is the only organization that enables mixed vendor Dynamic Streetlight Control solutions.

The ISO/IEC 14908 control networking standard has played a pivotal role in transforming vertical markets in the automation world. From commercial buildings, public transportation systems, industrial plants to home automation, electricity metering infrastructure and Olympic venues, applications built on the LONMARK standard are everywhere. Millions of devices have been installed around the world in home, building, and utility automation systems. The platform’s proven system architecture scales to millions of devices. For example, more than 27 million homes in Italy are connected to a smart energy infrastructure using powerline signaling technology.

Cities, manufacturers and maintenance operators have adopted LONMARK based Dynamic Streetlight Control Solutions for the following reasons:

- **Open and multi-supplier:** More than 20 hardware manufacturers offer compatible Light Point Controllers. All these modules are compatible with each other, can be mixed on a streetlight segment and controlled by the same Segment Controller or Gateway. In case one fails, it can be replaced by another one from another manufacturer.



Cities cannot afford to waste public investment. Thus, they can't engage budget in proprietary systems. Here are a couple of examples of street light projects

In 2009 an installer selected a wireless light point control system and planned to provide this system to a city as part of a Public Private Partnership contract. After 2 years of trials, technical problems and tests in the streets, with major investment from the installer (trucks, people, time) and penalties from the city to the installer, the proprietary wireless control system supplier filed for bankruptcy. The installer had no choice but make additional investments to uninstall the whole system. They replaced it with an open system based on the LONMARK interoperability standard. The system was installed in a few days and provided the expected energy and maintenance savings expected by the customer.

In 2013, the city of Paris decided to deploy interoperable Light Point Controllers in several parts of the city. The city's contractor started to select qualified Light Point Controllers. They could select 4 vendors/models from Osram, Citylone, Rongwen and Lumnux that are all compatible with each other and can be mixed on various projects.

- **Proven and robust:** There are over 450 successful projects and more than 700.000 light points installed in 15 countries (i.e. estimated 60% market share). Thousands of control applications based on the LONMARK interoperability standard are in use today in homes, offices, plants, transportation and other markets in Europe, America and Asia.
LONMARK certified products used in powerline networks even operate in areas with poor powerline communication quality. Unlike some proprietary protocols, it provides control and monitoring (bidirectional communication) to enable lamp command and feedback. Installations have been installed on dedicated electrical networks (such as those for streetlights) as well as mixed electrical networks (such as those that supply houses and buildings, as well as streetlights like most of the cities in the U.K.).
- **Evolutive from cabinet control as well as light point control:** cities can control their streetlight cabinets to benefit from maintenance enhancements at low cost. Cities such as Oslo and Paris decided to deploy smarter cabinet controllers, to have the opportunity to later extend to light point control and get the full benefits of the solution.
- **Available with Powerline and soon Wireless IPv6:** most Dynamic Streetlight Control Solutions currently installed on the market based on the LonMark interoperability standard use powerline as the primary communication media. Wireless devices supporting IPv6 addressing is currently being tested and should be released soon.
- **Dynamic lighting:** the LONMARK platform and associated Central Management Software enables users to define a sensor-based system. Thanks to broadcast and peer-to-peer communication capabilities, LONMARK based solutions enable sensor-based "train of light" or "follow me" lighting scenarios to save even more energy, while keeping the right light level at the right time.
- **Smart city applications:** sensor manufacturers can easily implement products and systems based on the LONMARK interoperable protocols to sell and install sensors on streetlight poles, that can benefit from the existing streetlight control infrastructure to collect sensor data, trigger alarms, generate reports and other applications.

Best practice: open Central Management Software

Central Management Software is required to configure, install, control and monitor a streetlight network from anywhere - a central Network Operating Center, a city or contractor's office or a service car - at anytime. As shown in each streetlight control project, the Central Management Software, also called Streetlight Control and Monitoring Software, is an essential part of the overall solution. It provides valuable insight at each project phase: proof of concept, installation of the first field project, organization of the deployment, confirmation of the ROI and verification of deployment and maintenance tasks.

An important aspect of using this type of application is that it allows the user to define administrative units in order to manage different deployments in different geographical areas. Each user has access to its own area, while the supervisor manages all installations, everything incorporated in the same software application.

Central Management Software creates new business opportunities for streetlight maintenance contractors to provide Network Operation Centers where they operate the Central Management Software as an online service (Software as a Service - SaaS - or Cloud), from where they can manage multiple cities to lower overall costs.

Also, the software supplier must provide to the end-user the possibility to purchase the license of the Central Management Software in order to install it on his own server.

Central Management Software is key in PFI/PPP (Public Private Partnership) contracts, where PPP contractors are committed through binding service level agreements and minimum energy savings. Central Management Software provides neutral key performance indicators to both the city and the contractor. It enables the PFI/PPP contractor to manage dimming levels, i.e. energy consumption, according to their energy savings commitment and evolution of the price of energy during the PFI/PPP contract timeframe (from 10 to 25 years). It also enables them to manage their maintenance budget, control luminaire suppliers by analyzing the behavior and energy consumption of their products.

The Central Management Software is also a bridge between streetlight assets and the city's existing IT system and business processes. With web-service based Central Management Software as specified in the previous section, all data collected are transformed into valuable information and services that are available for work-order management applications, energy billing systems, geographical information systems and smart city platforms. The Central Management Software hides the technical complexity of underlying hardware and protocols for end-users and such third party systems.

About the LONMARK International Organization

LONMARK International enables an evolution in street lights whereby smart communicating luminaires offered by a variety of suppliers can be connected in a single wired or wireless network. LONMARK International is a member-based organization that publishes guidelines and certifies products for conformance with the ISO/IEC 14908 series of standards for networked control. This standardized approach reduces the cost of installing and supporting systems over their lifetime by eliminating proprietary solutions offered by most vendors today.

LONMARK International is expanding its industry recognized interoperability guidelines and device profile architecture to support the rapidly growing market for Industrial Internet of Things (IIOT). This new standards-based architecture will expand the number of connectivity options for street lighting networks leveraging the proven LONMARK interoperability model.

To learn more about LonMark International and its street lighting initiative, please visit <http://www.lonmark.org/connection/solutions/lighting/streetlighting>

Customer Case Studies

A scalable solution for small to large cities

The best practices as described earlier are adopted by many streetlight maintenance operators, manufacturers and cities in China, South East Asia, Australia, South America and Europe. LONMARK based solutions are not only designed for large cities. The benefits apply to cities of all sizes:

- Smaller cities such as Sénart en Essonne, whose streetlights are monitored by professional streetlight maintenance operators can also take full benefit of the same system. Thanks to the Streetlight.Vision Central Management Software, streetlight maintenance operators can mutualize the overall cost on many smaller cities in a single Network Operating Center. Cities access and display information related to their own streetlight network, while maintenance operator can have custom views of the installed systems.
- Large cities such as Oslo, Norway, have reduced the overall costs associated with their streetlight network by almost 50%.

Solutions are deployed in more than 450 cities in 15 countries including Paris, Lyon, Metz, Brest, Rouen, Moissy, Sénart (France), Barcelona, Badalona, Terrassa (Spain), Portuguese Highways (Portugal), Polish Highways (Poland), Arahova (Greece), Dublin, Cork City (Ireland), Oslo, Trondheim (Norway), Cadeyreta (Mexico), Porto Alegre (Brazil), Santiago (Chili), Jakarta (Indonesia), Dongguan, Cheng'An, Forshan, Guangzhou, Wuxi (China), Daejon (Korea), Christchurch (New Zealand), Adelaide, Perth (Australia), etc...

Find additional informational about other customer case studies below:

- Multi-Vendor Project of the Year for 2013 — Small repeatable Solution : Guangdong Rongwen Lighting Co., Ltd for District of Guangcheng in Dongguan, China. Guangdong Rongwen retrofitted the street lighting system of the district of Guancheng in Dongguan, China as part of a larger initiative of creating intelligent, efficient and low-carbon city management solution. Leading the upgrade, the Dongguan Guancheng Utility Service Center was tasked with replacing nearly 12,500 street and alley lights while integrating an intelligent control system that communicates with the greater city management system: http://www.lonmark.org/connection/case_studies/documents/Guancheng%20Case%20Study_v2-1.pdf
- SPIE, a large installation and maintenance company with dedicated services for street lighting, fulfilled 6 Public Private Partnership contracts with cities in the south of Paris, France, thanks to the LONMARK solution provided by Streetlight.Vision, resulting in savings on energy, maintenance costs and CO₂ reduction of 900 tons: http://www.lonmark.org/connection/case_studies/documents/South_Paris.pdf
- Oslo, Norway, a pioneer in saving energy on their streetlight network has deployed LONMARK based streetlight control solution with Streetlight.Vision. More about the Oslo project at: http://www.lonmark.org/connection/case_studies/documents/Oslo_Streetlighting.pdf
- The well-known Place Bellecour in Lyon, France, is part of a global renovation project launched by Grand Lyon, that includes renovation of public lighting led by the French light engineering office "Les Eclairagistes Associés", based on a LONMARK solution provided by Citylone: http://www.lonmark.org/connection/case_studies/documents/Bellecour_Place_Lyon_Streetlighting.pdf

- Dutch highways: In view of plans to introduce a high-speed train, the Dutch government decided to renew a major part of the A16 highway between the Galder and Klaverpolder junctions, a distance of 23 km, and to build four major cloverleaf highway junctions. Implementation was delivered by the Philips Telemanagement team. More information about this project at: http://www.lonmark.org/connection/case_studies/documents/Netherlands_StreetlightingA16.pdf
- Using Flashnet's street lighting management system, Brasov becomes the first Smart City in Romania. By the end of 2014, 10,481 street lighting fixtures across 399 streets in Brasov will be remotely controlled by the Flashnet's solution, but the financial savings have already been observed after the installation of the first equipment: the energy costs are already reduced by 30%, while overall operational costs decrease by up to 42%. As Flashnet's solution is based on open protocols, it provides complete compatibility and interoperability with multiple vendor agnostic controllers, sensors and countless Smart applications, thus providing the potential to evolve into a complete, future proof Smart City infrastructure, one of the first in Eastern Europe. http://www.lonmark.org/connection/case_studies/documents/Brasov%20Case%20Study-1.pdf

Take your share of a fast growing market

Due to the growing awareness of climate change and the rising cost of electricity, cities are deploying solutions that have proven to save energy and increase service quality, while enabling future possibilities.

Rapid Market Growth for the LONMARK based Solution: a market opportunity for you

The number of installations in Europe and Asia has grown rapidly in the last few years. Streetlight maintenance companies are rolling out LONMARK based solutions in more and more cities every day. Cities now benefit from a significant catalog of more than 30 different models of interoperable Light Point Controllers from various manufacturers (Osram, Rongwen, Thorn, Philips, Citylone, Amko, Apanet, Sysplug, Lumnex, ...), which are compatible with all LED dimmable luminaires, HID electronic dimmable ballasts and even with HID old magnetic ballasts.

Back in 2006, there were only 4 manufacturers of LONMARK-compatible Light Point Controllers. Today, there are more than 20 manufacturers supporting the LONMARK technology. There were less than 10 streetlight maintenance operators trained to the system in 2009, while today there are nearly 50 maintenance companies.

The Streetlight Control market is now becoming a high-volume and high-value market. From 90 M€ in 2012, it is expected to reach 256 M€ in 2016 and 494 M€ in 2020 (McKinsey – Global Light Market study – 2012). For manufacturers involved in the streetlight industry, outdoor environmental sensors or maintenance operators, this is an exciting high growth market opportunity.

Extending the network beyond streetlights

LONMARK based solutions make it possible to easily extend the solution to collect environmental data such as pollution ratio, humidity, temperature, car traffic, energy, gas and water meters, street noise levels, etc. Cities can use this information to increase their knowledge database for strategic planning. With LONMARK based solutions, the investment to install the infrastructure (segment controllers, telecommunication network and Central Management Software) can be reused for many other applications.

Thanks to its openness, the LONMARK platform is a strategic tool for cities to increase their control while optimizing their budgets and saving energy. Dynamic Streetlight Control Solutions also offer maintenance operators and other service companies a unique and strategic opportunity to develop new added-value services and new profitable business models.

Most streetlight maintenance operators are starting to take advantage of such open solutions and share the financial rewards with cities by creating strategic Public Private Partnerships. Through such contracts, streetlight maintenance companies are gaining control over public infrastructure projects and can later operate this infrastructure for other applications, such as traffic control, environmental data collection, to support advertising panels, EV charging stations or WiFi spots.

The same maintenance contractors have also started to provide cities with a full service package to resell Lighting as a Service, which require drastic control over each individual light point. Open Dynamic Streetlight Control Solutions enable new business models, offering early adopters a strategic differentiator and attracting new players that are active in adjacent vertical markets.

*Control networks based on LONMARK interoperability
standard are fundamentally changing the way we think
and interact with the devices that surround us.*