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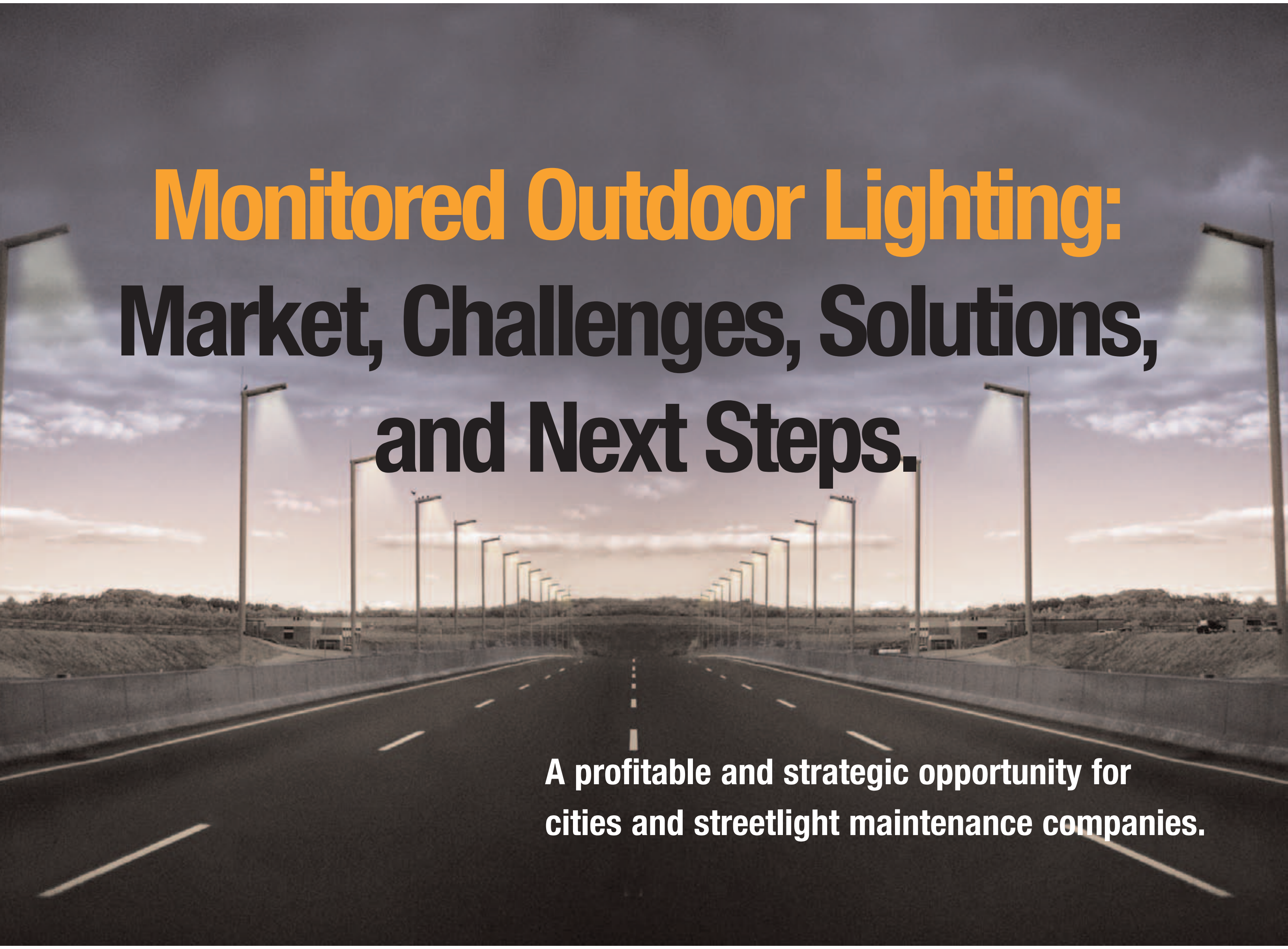

Monitored Outdoor Lighting: Market, Challenges, Solutions, and Next Steps.

A profitable and strategic opportunity for cities and streetlight maintenance companies.

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The Street Lighting Market

Streetlights: Valuable but Expensive City Assets

Streetlights are among a city's most important assets, providing safe roads, inviting public areas, and enhanced security in homes, businesses, and city centers. They're usually very costly to operate, however, and they use a lot of energy—almost 40 percent of a city's electricity spending. Most streetlight manufacturers haven't leveraged technology to address these issues, but as the cost of electricity continues to rise, it's becoming crucial that they do so. Cities that create managed streetlight networks can not only offer additional features but can also save energy, increasing their value as municipal assets.

The Cost of Operating a Streetlight Network

Besides the obvious electricity costs, operating a streetlight network requires several other expenses:

- Buying new lamps to equip new areas and to replace those that have failed
- Retrofitting old lamps to make them more efficient
- Managing crews of streetlight specialists and service trucks to identify lamp failures and fix them onsite

Several key factors are increasing streetlight network operating costs:

- In general, streetlights in Europe and North America are old and deteriorating. A 1998 U.K. survey by the Institute of Lighting Engineers (ILE), the Lighting Column Manufacturers Association (LCMA), and the Association of Street Lighting Electrical Engineers (ASLEC) found that about 800,000 of the lighting columns in the U.K. must be urgently replaced, at a total estimated cost of £500 million. The study also found that, before 2008, an additional 3 million streetlights will have exceeded their design life of 25 years, and will need to be replaced.
- The average lamp lifetime is 12,000 hours, or four years. Therefore, identifying failed lamps, anticipating the end of a lamp's lifecycle, and changing lamps is a significant part of the streetlight operating budget. For example, a city of 100,000 people (which, using the formula of 1 streetlight for every 6 inhabitants, translates into about 16,700 streetlights) spends approximately $100,000 per year simply buying new lamps (this doesn't include installation costs).
- Replacing lamps, and identifying and fixing other problems in the streetlight network require manpower and tools. Depending on the country and contractor, the average maintenance cost is estimated at $250 for a one-hour onsite operation.
- Worldwide, the price of electricity has increased drastically over the last five years. Analysts are forecasting a continuous increase over the next 10 years. Table 1 (page 4) lists the price of electricity per country and the price increase over the last five years.

  The streetlight network is a city's primary consumer of electricity, representing almost 40 percent of a city's electricity spending (38 percent in France in 2000 – *source: ADEME*). The annual electricity cost to illuminate a city of 100,000 people is more than $900,000 in most countries. The number of streetlights, the wattage of the lamp and its ballast (average 140 watts), and the number of hours during which the lamp is burning (average 4,000 hours per year) all contribute to the total cost.

Rank	Country	Average Price per KWh of Electricity ($)	Electricity Price Increase in Past 5 Years
1	Denmark	$0.143	**+ 39% (Rank 5)**
2	Italy	$0.142	+ 14.9% (Rank 8)
3	U.K.	$0.118	**+ 41.4% (Rank 3)**
4	Netherlands	$0.118	+ 27.4% (Rank 6)
5	France (deregulated market)	$0.113	**+ 48% (Rank 1)**
6	Belgium	$0.112	+ 14% (Rank 9)
7	Germany	$0.110	+ 7.5% (Rank 11)
8	Spain	$0.099	+ 15.5% (Rank 7)
9	U.S.	$0.094	+ 10.9% (Rank 10)
10	Finland	$0.086	**+ 42% (Rank 2)**
11	Sweden	$0.074	**+ 39.1% (Rank 4)**
12	France (regulated market)	$0.068	+ 0% (Rank 15)
13	Canada	$0.063	+ 5.5% (Rank 12)
14	Australia	$0.057	+ 2.8% (Rank 13)
15	South Africa	$0.043	+ 2.3% (Rank 14)

Table 1: Average price of electricity and 5-year price increases *(source: NUS)*

(30% price increases are in bold)

Streetlights Cause Carbon Dioxide (CO^2) Emissions

Besides being costly, streetlights contribute to air pollution. The production of electricity needed to power street lighting systems adds to carbon dioxide emissions (CO^2 is the principal “greenhouse gas”) and nuclear dust. Light pollution also has a negative effect on the environment, impacting plants, animals, and people’s sleeping habits. Table 2, below, provides an estimate of electricity use and the associated CO^2 emissions for some areas.

Location and Number of Residents	Estimated Number of Streetlights	Estimated Number of KWh per Year	Estimated Annual Electricity Cost for Streetlights	Estimated Annual CO^2 Emissions due to Streetlights (in tons)
U.S.	> 68 million	> 300 billion	> $18 billion	> 150 million
European Union	> 90 million	> 450 billion	> $45.5 billion	> 180 million
U.K.	7.5 million	> 4 billion	> $650 million	> 1.9 million
France	8.6 million	5.3 billion	$520 million	583,000
Los Angeles (U.S.)	220,000	> 100 million	> $17 million	> 60,000
Paris (France)	170,000	> 80 million	> $10.2 million	> 9,000
Want to get an idea for your city? (Estimates based on average figures in Europe)				
If N is the number of residents in your city	Streetlights (S) = N / 6	E = S x 490	B = E x 0.09	CO^2 = E x 0.45
Example for a city of 60,000 residents	10,000 streetlights	4.9 million KWh per year	$440,000	2,200 tons of CO^2

Table 2: Streetlight market — Estimate of electricity use and associated CO^2 emissions

Using electricity means being responsible for CO^2 emissions. Power-generation plants emit CO^2 into the atmosphere, accounting for almost 34 percent of Europe's overall carbon dioxide emissions (*source: EasyJet magazine, November 2006*). Producing one KWh of electricity with a nuclear plant generates about 100 grams of CO^2, while producing one KWh of electricity from a coal plant produces one kilogram of CO^2. Table 3 provides the CO^2 emission rate for Europe's 15 main electricity providers.

Rank (production in billions)	Energy Provider and Countries Supplied	CO^2 Emissions (tons of CO^2)	Grams per KWh
1 (586)	EDF – France, U.K., Germany	60 177 873	103
2 (183)	RWE – Germany, U.K.	139 100 000	**783**
3 (167)	Vattenfall – Sweden, Germany, Poland, Finland	66 433 000	410
4 (155)	E.ON – Germany, U.K.	70 842 000	410
5 (132)	Enel – Italy, Spain	68 421 000	**518**
6 (128)	Endessa – Spain, Italy, France	70 450 173	327
7 (125)	Electrabel – Belgium, Netherlands	40 825 000	327
8 (67)	British Energy – U.K.	7 155 000	106
9 (66)	Iberdrola – Spain	11 899 215	179
10 (62)	CEZ – Czech Republic	35 706 546	**575**
11 (61)	Edison – Italy	34 703 400	**569**
12 (56)	Fortum – Finland	10 387 872	167
13 (53)	DEI – Greece	53 287 500	**1015**
14 (41)	Essent – Netherlands	19 680 000	464
15 (39)	EDP – Portugal, Spain	23 693 710	**612**

Table 3: CO^2 emission rate for Europe's main energy providers
(Source: PriceWaterHouseCoopers and Enerpresse, November 2005)

(500 grams of CO^2 per KWH are in bold)

Why Cities Will Adopt Monitored Streetlight Systems

The cost and environmental factors described above are pushing cities to find solutions that reduce their streetlight network costs while improving light efficiency and safety. 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 in order to reduce energy spending, decrease maintenance costs, challenge their electricity providers, and contribute to the reduction of CO^2 emissions, as required by the Kyoto Protocol and various other European initiatives.

Lighting Efficiency

To follow minimum lighting requirements and reduce electricity and maintenance costs, the outdoor lighting market has recently adopted two major technology advancements—high-pressure sodium (HPS) lamps and electronic ballasts—which help make lighting more efficient.

While HPS lamps have been widely adopted, the deployment of electronic ballasts began ramping up only in 2005. Despite significant electricity savings and a longer lamp life, the first generation of electronic ballasts were not robust enough to offer the long life that the streetlight market needs. Moreover, their price was high due to low volumes. Today, electronic ballasts are being been deployed more quickly thanks to:

- Environmental directives and laws (such as the European 2000/55/EC directive) that have reduced the maximum electricity consumption of the ballast,

- More competitive pricing, and
- A new generation of programmable electronic ballasts that can be remotely dimmed and can automatically identify and communicate lamp and ballast failures in order to reduce maintenance costs.

Monitored Streetlight Networks: The Next Wave in Outdoor Lighting

The benefits of the new generation of electronic, dimmable, and communicating ballasts have been proven by the success of the first projects in Europe in 2004-2006 (see case study below) and by the 200-percent growth of pilot sites in 2006-2007. Monitored streetlight systems are the next wave in the outdoor lighting market.

Four drivers are causing cities to better control their streetlight networks:

- The environmental and energy situation of the planet
- The rapidly increasing price of electricity
- The need for more security and safety
- The need to efficiently manage budgets

Key Players and Their Roles

Cities, regions, and local authorities

Cities, counties, and other local authorities need ways to contain their expenses and limit local taxes without diminishing the level of service and security they provide to citizens.

For example, the portion of the British budget related to streetlight services is estimated at more than £280 million per year, of which 40 percent is spent on energy. The electricity costs for the city of Los Angeles, California, with 270,000 streetlights, is estimated at over $17 million per year. Streetlights are the main electricity consumer in a city.

As stated by the city of Oslo, Norway, in November 2004, cities that take advantage of today's new technologies and solutions can reduce the overall costs associated with streetlight networks by almost 50 percent, while increasing the quality of service and safety. The city of Oslo and its energy supplier have shown that deploying a solution based on electronic programmable and dimmable ballasts that identify and communicate failures over power lines using a standardized protocol can pay for itself immediately (*source: Hafslund presentation, November 2004*).

Streetlight maintenance providers

Large facility managers and maintenance providers in France and the U.K. (such as SPIE, SUEZ, and D.WEBSTER/ETDE) are adopting strategies and deploying technologies to take a leading and long-term advantage in the streetlight business. Implementing an online monitoring solution for streetlight networks is a way for them to win new maintenance contracts with cities, as well as to open new, profitable business opportunities in other areas of the city, including energy distribution and management, environmental monitoring projects, electrical and communication networks, and integrated building automation.

In Europe, operating one streetlight costs, on average, €100 per year ($130). As shown in cities such as Oslo, monitoring streetlights can save as much as 60 percent in maintenance costs and 30 percent in electricity costs. Most streetlight maintenance providers are starting to take advantage of such solutions and share the financial rewards with cities by creating strategic public/private partnerships. Through such contracts, private streetlight maintenance companies are gaining control over public infrastructure projects and can later exploit this infrastructure for other applications, such as traffic control, environmental data collection (to monitor air pollution, for example), or to support multimedia advertising and Internet antennas.

Some of these service providers may even contract with cities to buy the streetlight network and resell it as a recurrent monthly lighting service. In other words, solutions such as those described further in this document enable a new business model in the streetlight market, offering early adopters a strategic differentiator and attracting new players that are active in adjacent vertical markets. For example, energy providers are creating streetlight maintenance subsidiaries in order to protect and increase their energy market share. Citelum, a large streetlight maintenance company in France, is a subsidiary of EDF. Rhein Energy, the German energy provider, is maintaining the streetlights in many cities in Germany. Ineo, a large streetlight maintenance company in France, is part of the Suez/Electrabel energy/electricity group.

Ballast and luminaire manufacturers

Ballast and luminaire manufacturers have invested in research and development to benefit from the business opportunity created by rising electricity prices and the growing need for more-efficient lighting. The success of large-scale monitored streetlight projects based on Echelon's open LonWorks® technology is pushing manufacturers to deliver electronic dimmable ballasts that can communicate using an open (not proprietary) protocol.

Ballast manufacturers such as SELC (Ireland) and Philips Lighting Control (Netherlands) have been early adopters of such solutions. SELC's electronic ballasts are equipped with a communication node that leverages the LONWORKS technology. Philips Lighting's electronic ballasts can be enhanced with a LONWORKS based outdoor lighting controller (OLC) designed by Philips that lets you control the ballast from anywhere, at anytime. Other manufacturers that have developed similar solutions based on proprietary protocols are now studying ways to adopt open technologies, such as the LONWORKS platform, in the next generation of their products so they can bid on existing and upcoming projects.

Other industrial players market independent LONWORKS based, power-line outdoor lighting nodes to control and monitor existing magnetic and electronic ballasts. Such products are fully compatible with the recommended monitoring streetlight solution described below, even though they may save energy only when used with dimmable ballasts.

The Challenge for Cities

The challenge for cities regarding their streetlight networks is to increase the quality of service while reducing the operational budget. While citizens consider streetlights a critical public service and complain loudly about lamp failures, they also want city governments to examine and reduce budgets.

Enhance Lighting Services for Citizens

Light quality (reduced downtime, selected color rendering, and enhanced street visibility) is directly linked to driver and pedestrian comfort. A number of studies show how improved street lighting reduces crime (refer to Home Office Research – Study 251 from David P. Farrington and Brandon C. Welsh, August 2002, which mentions a few studies in the U.S. and the U.K). Most found a marked reduction of crime following re-lighting (Source Hartley, 1974). As noted in "The Influence of Streetlighting on Crime and Fear of Crime" (Crime Prevention Unit Paper n°28, London Home Office, 1991), "Improved street lighting is not only favored by many crime prevention professionals, it is also one of the most common suggestions made by people fearful in their use of public open spaces as a means of both crime prevention and fear reduction."

To enhance public lighting services, cities and their subcontractors need highly efficient lamps and luminaries that offer more lumens (the amount of light on the ground) for less electricity while providing a longer lamp lifetime.

Cities also need ways to anticipate and identify lamp failures so they can group onsite replacement operations, thus limiting maintenance costs.

Here is the best-practice solution to address these issues:

- ***Relamp*.** Lamp technologies are now more robust, offering better lighting efficiency (the number of lumens per watt) and longer lifetime (more than 12,000 hours, or over 3.5 years for a high-pressure sodium lamp).

- ***Install electronic ballasts*** that regulate the current/voltage delivered to the lamp and handle lamp ignition more efficiently. Current electronic ballasts reduce the risk of lamp failure by as much as 30 percent and increase average lifetime by 25 percent. This reduces the number of onsite operations.
- ***Deploy a monitoring system.*** Ballasts can now be complemented by an electronic outdoor lighting node in the luminaire to automatically:
  - Identify ballast and lamp failures.
  - Measure electricity consumption and other electrical data.
  - Report lamp burning hours.
  - Provide other data (such as ballast temperature) that's helpful when troubleshooting a problem, thus reducing maintenance time and costs.

  Streetlight monitoring software can make it easy to configure, install, and monitor a streetlight network from anywhere—a central service center, a city or contractor's office, or a service car—at anytime. Streetlight maintenance companies can operate this software as an online service, and thus monitor multiple cities.

Reduce Electricity Costs and Maintenance Budgets

To reduce streetlight network operating budgets, cities and subcontractors must:

- Reduce the number of onsite operations,
- Cancel the night maintenance crews that visually identify lamp failures from a service car,
- Lower electricity consumption while increasing overall light efficiency, and
- Increase the average lamp lifetime.

Here is the best-practice solution to address these issues:

- ***Relamp.*** In 1999, a market study in France showed that 40 percent of the lamps in service could have been replaced with newer-technology lamps that would have delivered the same amount of light on the ground while consuming half the electricity. Even if relamping is expensive (requiring an initial inventory and study of light efficiency, lamp purchase, and onsite installation), the ROI for lamp changes is usually less than 18 months.
- ***Install dimmable ballasts***. Replacing conventional magnetic ballasts with electronic ballasts that can be dimmed during non-crucial hours can automatically save up to 45 percent on electricity use. Electronic ballasts alone generally consume less than 15 percent of what's consumed by conventional magnetic ballasts. Moreover, after several years of operation, the efficiency of magnetic ballasts rapidly declines, implying a higher consumption of reactive power, which is billed by some energy providers.

  Ever since the first streetlights were installed, cities have been tempted to switch them off in the middle of the night when less light is required. Such ideas were abandoned to prevent crime and avoid security and safety issues on city streets and parks. Nowadays, electronic dimmable ballasts offer a way to reduce (but not switch off) lighting in the middle of the night, thus lowering electricity use yet still providing a recommended level of light. Electronic ballasts can also be remotely controlled and dimming schemes can be programmed and applied remotely when needed, such as during firework displays, accident response, and exceptional weather conditions.
- ***Install voltage or power variators in a supply cabinet.*** Voltage/power variators can dim all the streetlights connected to a supply circuit. Such systems are expensive for small cabinets that supply less than 50 streetlights. They're less efficient when mixed-lamp technologies are installed on the electric network and with long networks with voltage losses, but they can save up to 25 percent on electricity use in ideal configurations.
- ***Deploy a monitoring system.*** Along with the ability to automatically identify lamp failures, electronic outdoor lighting nodes can dim ballasts through a scheduler installed in the supply cabinet or through

centralized monitoring software. Streetlight monitoring software can deliver a daily, consolidated, and detailed report of failures that were identified by electronic outdoor lighting nodes installed in each luminaire. It can also calculate business indicators, such as service levels and energy savings, and let operators remotely control streetlights in real time. Such systems negate the need for night maintenance crews and service trucks. Problems are identified automatically and can be investigated from a central service center, greatly reducing maintenance costs.

Additional Issues Related to Streetlight Networks

Cities also need solutions to help them:

- Reduce CO^2 emissions to comply with national and international environmental regulations and directives.
- Enhance the city's "green image" to attract new investors, companies, and inhabitants.
- Reduce light pollution.

The ideal streetlighting solution should address all the challenges mentioned above within a maximum ROI of seven years. In addition, the solution could leverage the streetlight infrastructure (luminaires and supply cabinets) as a support for other profitable applications such as collecting environmental data or using streetlight columns to support dynamic advertising.

Since cities have limited resources and skills to maintain streetlight networks, the ideal solution should be easy to install, configure, maintain, and use.

Solutions: Characteristics, Best Practices, and Benefits

	Electronic dimmable ballasts communicating over power lines, using open protocol **Category 1**	Electronic dimmable ballasts using proprietary communication protocols **Category 2**	Power or voltage regulator/variator installed in supply cabinet (dimming from cabinet) **Category 3**	Proprietary outdoor node to control existing ballasts using proprietary protocols **Category 4**	Failure detection at the supply cabinet level **Category 5**
Some of the solution providers	SELC, Philips Lighting	Sogexi, Tyco, Magnetek, Thorn	Salicru, IREM, Lubio (Schneider)	Edelcom, Ampex, UMPI, RPE	Any PLC with inputs/outputs
Energy Savings	**Up to 45%**	Up to 40%	Up to 20%	None	None
Dimming	Yes	Yes	Yes	No	No
Financial savings due to dimming	*> 30% with HPS and HID Lamps*	*> 30% with HPS and HID Lamps*	*20%*	*0%*	*0%*
Savings due to ballasts	*> 10%*	*> 10%*	*0%*	*0%*	*0%*
Scheduling and astro clock	Standard feature	Usually optional	Usually optional	Usually optional	Optional
Energy and CO^2 saving calculation	Yes	No	No	No	No
Increased service and reduced maintenance costs	**9 / 10**	5 / 10	2 / 10	6 / 10	4 / 10
Compatible with tender processes	Yes	Partially	Yes	Partially	Yes
# of failure types	Up to 10	Up to 5	Usually none	Up to 5	Up to 3
Increased lamp lifetime	+25%	+25%	No	No	No
Detects cabinet failures	Yes	Not with all solutions	Very rarely	Yes	Yes
Alarms via Web portal / cell phone	Yes	Cell phone only	No	Cell phone only	Cell phone only
Data aggregation and presentation in Web portal	Yes	No	No	No	No
Remote control and command	Yes	Not with all solutions	No	Yes	No
Supports data collection from any standard devices	Yes, from any LONWORKS and Modbus device	No	No	No	Optionally, for devices connected to the cabinet
Skills needed to install & configure	Network integrator	Network integrator	Electrical skills	Network integrator	Electrical skills
ROI	9 / 10	5 / 10	2 / 10	6 / 10	4 / 10
Average total price (per streetlight)	€290	€250	€110	€180	€40
Estimated ROI	< 7 years	< 9 years	< 6 years	< 9 years	< 5 years
Annual savings (per streetlight)	> €40	< €30	< €18	< €20	< €8
Functionality level	10	5	4	4	1

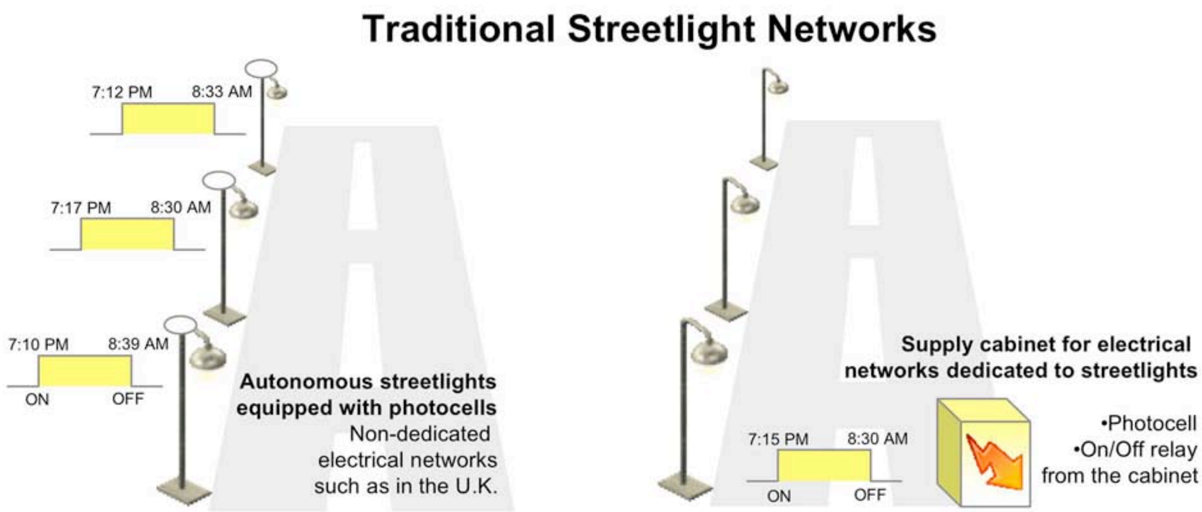
Table 4: Solutions — Comparative Study

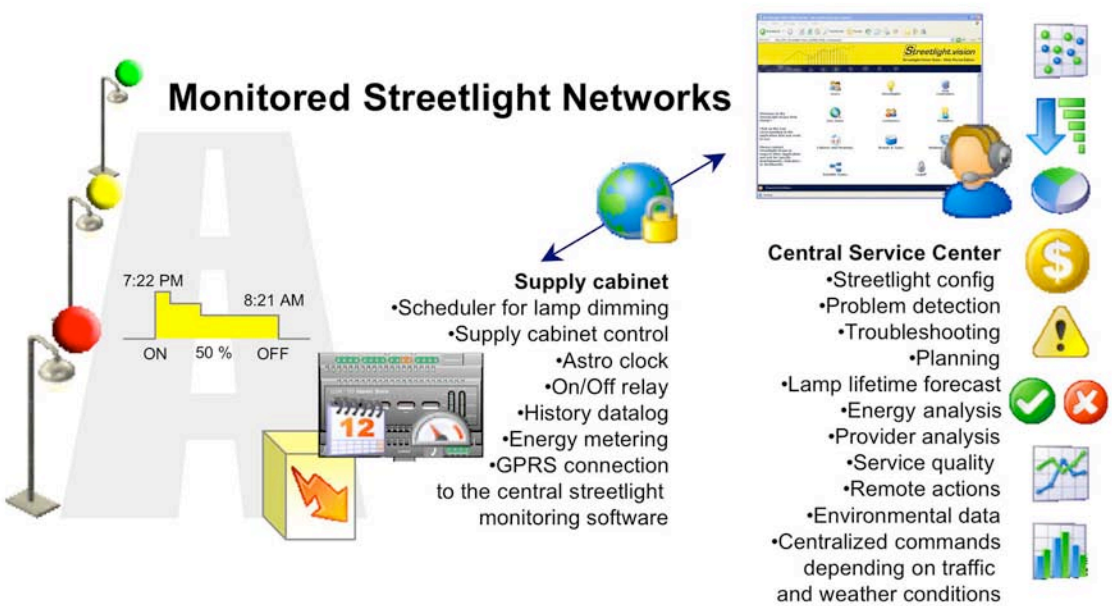
Source: Streetlight.Vision, March 2006

Time to Adopt and Deploy the Best Practices

The first step to increase streetlight efficiency while reducing maintenance and electricity costs is to take an inventory of all luminaires and lamps so you can identify streetlights that can be equipped with lower-wattage lamps while delivering the same (or more) light on the ground. Luminaires and supply cabinets are quite outdated in Europe and North America, and many cities are already issuing tenders to retrofit up to 25 percent of their luminaires and lamps.

Such retrofit projects are ideal opportunities to deploy the recommended solution: *LONWORKS based electronic dimmable ballasts controlled by streetlight segment controllers and centralized streetlight monitoring software.*





We recommend a monitored streetlight system based on the following components:

- ***Dimmable ballasts equipped with a LONWORKS node***, installed in the streetlight (preferably electronic ballasts). Ballasts must be:
    - Dimmable to reduce energy spending.
    - Able to auto-detect lamp and electrical failures.
    - Able to measure and send data such as lamp status, lamp level, accumulated energy consumption of the streetlight, voltage, current, and cos φ (for example, the ratio between active energy power and total energy power) over the power line network using the LONWORKS protocol.
    - Able to receive switch and dimming commands from a streetlight segment controller through the same media.
- ***Streetlight segment controllers*** located in the feeder pillar. The controller is the gateway between the central streetlight monitoring software and the ballasts. Thus, streetlight segment controllers must support standard communication layers including TCP/IP over GPRS, ADSL, WiFi, and WiMAX and provide a standardized Web service interface to receive data, send commands, and configure the streetlight controller's services. The controller must provide the following services within an integrated package:
    - Bidirectional communication to the LONWORKS node over power line
    - Historical datalog for several days
    - Astronomical clock to send lamp switch commands at dusk and dawn
    - Scheduler for dimming commands
    - Alarm notification to send messages of critical failures

  The streetlight segment controller must support additional protocols (such as Modbus) to communicate and control other types of devices (such as energy counters, door opening sensors, or heaters) installed in the cabinet.
- ***Streetlight monitoring software*** installed on a central computer in a service center. This software serves as the data aggregator for thousands of streetlight segment controllers. It must offer:
    - Administration tools to make it easy to install and configure electronic ballasts, LONWORKS nodes, and streetlight segment controllers.
    - Data aggregation methods to calculate failure ratio, business indicators, and energy consumption information.
    - Intuitive end-user tools to let maintenance operators quickly and easily identify lamp failures, display energy consumption and other service-level business indicators, and remotely control and command streetlights.

  The software is a bridge between the streetlights and the city's (or the streetlight maintenance company's) existing IT system and business processes. Information from the streetlight monitoring software can be leveraged by work-order management applications as well as by energy billing applications. The software also hides the technical complexity of monitoring streetlights and limits the skills required of end users and reduces installation costs.

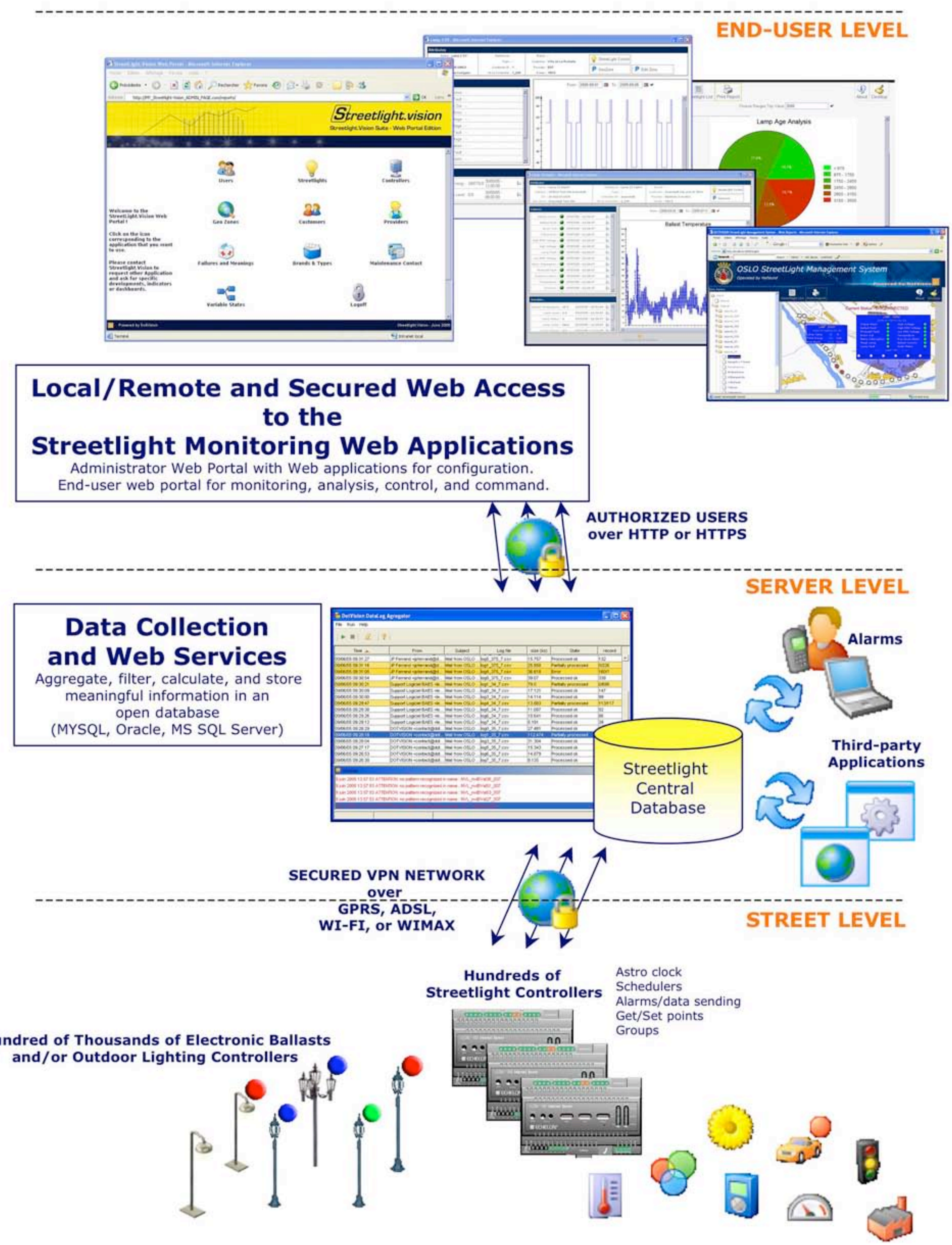
  With streetlight monitoring software that provides intuitive streetlight maintenance and business reports through a 100-percent secured Web access to end users, streetlight maintenance companies can give their customers an online subscription to monitoring and business information including service-level indicators.

> As shown in each project, streetlight monitoring software is an essential solution component since it provides valuable insight during each project phase: proof of concept, installation of the first field project, validation of the ROI, and verification of deployment and maintenance tasks.

The average streetlight's lifetime is 25 years. Thus, the components of the recommended monitoring solution must be based on open, flexible, and standard technologies that will benefit from a continuous evolution driven by many product manufacturers, as they will be supported for a longer timeframe than proprietary systems adopted by only a few companies.

Principles and Architecture of the Best-Practice Solution

The scheme below summarizes the architecture of the recommended solution:



The LONWORKS Protocol: The Best Underlying Technology for Streetlight Monitoring

Since its introduction more than 10 years ago, the LONWORKS platform has played a pivotal role in transforming vertical markets in the automation world. From commercial buildings, public transportation systems, and industrial plants to home automation, electricity metering infrastructure, and Olympic venues, applications built on the LONWORKS platform are everywhere. Millions of LONWORKS power line devices have been installed around the world in home, building, and utility automation systems. The platform's proven system architecture scales to millions of LONWORKS devices. For example, more than 27 million homes in Italy are connected to a smart energy infrastructure using Echelon's power line signaling technology.

Ballast manufacturers, integrators, and the early users of streetlight monitoring solutions have adopted LONWORKS based solutions for the following reasons:

- LONWORKS technology is robust. It's the underlying protocol in thousands of control applications in Europe, America, and Asia.
- LONWORKS technology is proven on power line networks, even those with poor power line communication quality. Unlike some proprietary protocols, it provides control and monitoring (bidirectional communication) to enable lamp command and feedback. Pilot sites 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.).
- LONWORKS technology offers interoperability. Electronic ballasts equipped with a LONWORKS node can be controlled by an astronomical clock that triggers a Modbus signal, for instance. This particularity lets the client find the best products at the best price.
- LONWORKS technology offers flexibility. Devices can be controlled and commanded. It's easy to remotely configure and update them—anytime, anywhere.
- LONWORKS technology offers a vision of the future. Because LONWORKS networks are scalable, solutions based on LONWORKS technology can easily evolve to support more devices and can monitor other types of devices from virtually any manufacturer, providing unmatched interoperability.
- Echelon's *i*.LON® 100 controller is fully compliant with the required features of the controller in the above recommended solution. The *i*.LON 100 offers full LONWORKS and Modbus control, as well as all the required streetlight services (astronomical clock, scheduler, data log, alarm, and a Web services interface for control, command, and configuration), and is among the least expensive streetlight controllers on the market today.

The next section describes one of the numerous streetlight monitoring projects that is leveraging LONWORKS technology.

Customer Case Study

The best practices described above have been adopted by most large streetlight maintenance companies in Europe and by most integrators and cities in Austria, Canada, France, Germany, Ireland, Norway, Spain, and the U.K. LONWORKS based solutions are not only designed for large cities; the benefits apply to cities of all sizes.

- Large cities such as Oslo, Norway, have reduced the overall costs associated with their streetlight network by almost 50 percent. (See Echelon's press release for more information: http://www.echelon.com/company/press/oslolights.htm)
- Smaller cities whose streetlights are monitored by large streetlight maintenance companies can also benefit. The recommended solution is based on a Web portal, which can handle multiple cities within the same database and server. Members of each city can access and display information related to their own streetlight network.

The Challenge

This case study describes a successful project installed in a seaside resort in Brittany, France, with 16,000 residents. International commitments to tackling climate change, rising energy prices, and European directives on energy efficiency moved the city to consider measures to reduce energy use. The city was also concerned about security and the efficient use of its citizens' taxes. In 2005, the city faced two main challenges:

- Reduce energy use to contain electricity costs while lowering CO^2 emissions by 20 percent.
- Reduce the number of lamp failures and lamp downtime to avoid potential security issues for drivers and inhabitants.

The Solution

SPIE, one of the largest streetlight maintenance companies in Europe, proposed a monitored streetlight solution from Streetlight.Vision, a software and consulting company specializing in streetlight monitoring and management. The Streetlight.Vision solution complies with this paper's recommended solution and is installed in various cities across Europe and North America.

Before deciding to deploy the solution to the city's 120 supply cabinets and 3,100 streetlights, the city and SPIE decided to first install it in a pilot site in November 2005, and measure its benefits over 12 months. The pilot site included one cabinet and 44 streetlights.

The solution is comprised of the following components:

1. Each luminaire is equipped with a 70W, 100W, or 150W electronic dimmable ballast from SELC (Ireland). The ballasts communicate using Echelon's power line technology and a LONWORKS node that's also installed in the luminaire, as a complement to the ballast.
2. Each supply cabinet is equipped with Echelon's *i*.LON 100 Internet Server (also called a streetlight segment controller). The *i*.LON 100 enables bidirectional communication over GPRS with the central Streetlight.Vision streetlight monitoring software. It uses its internal astronomical clock to automatically switch the mains on and off, and to dim the ballasts at night to save electricity when less light is needed.
3. France Telecom, France's largest telecommunications operator, is providing a Virtual Private Network over its GPRS network.
4. The Streetlight.Vision M2M Data Collect software collects, aggregates, transforms, filters, and stores data from all streetlight segment controllers in a central, open database that's installed at the SPIE IT center in Paris. The Streetlight.Vision M2M software collects data from multiple cities, enabling SPIE to resell the solution as an online service through monthly subscription.
5. The Streetlight.Vision Web Portal provides intuitive Web reports for maintenance operators (including failure detection and troubleshooting reports) and managers (including service quality indicators and energy use analysis reports).

Benefits

As shown by the Streetlight.Vision monitoring software and confirmed by the city and SPIE, the solution provides the following benefits:

- Electricity use was reduced by 46 percent, resulting in a roughly 30-percent reduction in streetlight electricity costs. The projected electricity cost savings is $80,000 per year.
- The city expects to reduce carbon dioxide emissions by 70 tons per year, corresponding to the 46-percent reduction in electricity use.
- Because lamp failures can be identified within hours, average lamp downtime was reduced by 90 percent.

- Alarms are triggered when lamp voltage exceeds recommended levels, preventing future lamp failures.
- Since electronic ballasts regulate high-pressure sodium lamps, the city expects to save 20 percent in lamp replacement costs.
- Since software enables most operations to be performed remotely, the number of onsite maintenance operations has been reduced by at least 30 percent.

The *i*.LON 100 can serve as a gateway for a variety of devices types. It provides:

- Universal connectivity for devices attached to it, making their data available to the city's IT system through Streetlight.Vision's software.
- Local device monitoring and control via built-in scheduling, alarming, and data logging applications.
- An astronomical clock, which is used to automatically switch on and off lamps, thus saving energy when compared to a fixed scheduler.

In this project, Echelon's *i*.LON 100 is used as the streetlight segment controller to log and report lamp failures, lamp behavior (dimming level and voltage), energy consumption, and burning hours. It may later collect information from traffic and weather sensors to adapt lamp dimming levels. The astronomical clock switches lamps off and on depending on the position of the sun. Lamps are dimmed at a fixed time, thanks to the *i*.LON 100's internal scheduler, during low activity hours at night. This highly efficient method of controlling light levels results in significant energy savings. Lamp lifetime is extended due to the way electronic ballasts regulate the lamp.

Next Steps

The pilot project, completed in November 2005, was so successful that the city decided to extend it to 3,100 more luminaires within the next 18 months. SPIE is now recommending and deploying the solution to all of its clients. Many cities and governmental organizations in France and Belgium have been impressed by the benefits mentioned above and will begin similar projects soon.

The mayor of the city is convinced of the benefits of LONWORKS solution. In a promotional video he says, "The SPIE company has helped provide the municipality with a cost-effective solution that is saving us a lot of money over the next few years, while contributing to our strategic sustainable development plan. We're now working to extend it to the entire city."

Control networks based on LONWORKS technology are fundamentally changing the way we think and interact with the devices that surround us.

Alternative Solutions

Table 5 lists the results of alternative solutions used by other French cities.

City	Solution that was tested and scope	Energy saving (% of KWh)	Maintenance benefits	Is a deployment planned ?
ROANNES 7,500 lamps –	VRI Lubio Schneider Electric Category 3*	31%	No failure detection. Lamp lifetime to be demonstrated.	Yes
ANNEMASSE	Illuest from Salicru Category 3*	19%	No failure detection. Lamp lifetime to be demonstrated.	No
PIERRELATTE 2,995 lamps	Electronic ballast from SOGEXI Category 2*	36.3%	No failure detection. Lamp lifetime to be demonstrated.	Unknown
PIERRELATTE 2,995 lamps	VRI Lubio from Schneider Electric Category 3*	23.4%	No failure detection. Lamp lifetime to be demonstrated.	Unknown
PIERRELATTE 2,995 lamps	RPE from JCL2000 Category 4*	22%	No failure detection.	Unknown
MACLAS	Reverberi Category 3*	29%	No failure detection.	Unknown
BRON	VRI Lubio from Schneider Electric Category 3*	28%	Limited failure detection due to a hardware add-on in the cabinet (Category 6*).	No

** Categories refer to Table 4 on Page 10.*

Source : ENTPE – Nicolas Reynaud – "La maîtrise de l'énergie en éclairage public," June 2005

Unlike the recommended LONWORKS solution, the solutions above do not reduce maintenance and energy costs, as do the best practices described in this paper.

Contrary to proprietary and limited solutions, LONWORKS based solutions also offer compelling benefits in term of control, visibility, and increased service of quality. They also let cities leverage the infrastructure to receive additional benefits through future control applications in streets and buildings, thus providing an even more attractive ROI.

What's Next?

Due to the growing awareness of climate change and the rising cost of electricity, cities are keen to deploy solutions that have proven to save energy and increase service quality, while providing a clear vision about future possibilities.

Rapid Market Growth for the LONWORKS based Solution

The number of pilot sites in Europe has grown from less than five in 2005 to more than 30 in 2006. Streetlight maintenance companies such as France's SPIE are planning to roll out the solution in more than 50 cities in France and Belgium in 2007. Since September 2006, 12 new streetlight maintenance companies and integrators have begun testing LONWORKS based solutions and proposing them to their customers in Europe, Canada, and the U.S.

Extending the Network Beyond Streetlights

LONWORKS based solutions make it possible to easily extend the solution to collect environmental data such as pollution ratio, air composition, humidity, temperature, traffic, and street noise levels. Cities can use this information to increase their knowledge database for strategic planning. With LONWORKS based solutions, the investment to install the infrastructure (including segment controllers, a telecommunication network, and monitoring software) can be reused for many applications.

We expect that more than half of the cities that evaluate a LONWORKS based streetlight monitoring solution will deploy it and then further extend the network to other application domains within the next 24 months. LONWORKS based streetlight monitoring solutions will become city monitoring solutions.

Thanks to its openness, the LONWORKS protocol offers a strategic tool for cities to increase their control while optimizing their budgets. The technology offers service companies a strategic opportunity to develop new added-value services and new profitable business models.

LONWORKS Technology Promotes Rapid Growth in the Monitored Streetlight Market

The monitored streetlight market is now becoming a high-volume and high-value market. In 2007, we expect that 150 additional European cities will install a monitored streetlight pilot site involving LONWORKS devices. In addition, 30 cities that piloted installations in 2006 will decide to deploy the solution and fully benefit from it.

Few ballast manufacturers and solutions providers have taken a leading advantage in this market. You can help accelerate the growth of this market. Contact Echelon and its business partners today and help reduce energy use on the planet.