ECHELON

OUTDOOR STREET LIGHTING

Making Outdoor Lighting More Efficient, Safe, and Affordable With Open-Standard Control Networking Technology

Overview

Modern commercial outdoor lighting systems are being asked to do more than ever before. In addition to fulfilling their primary purpose of casting light onto dark roadways, parking areas, and public spaces, outdoor lighting systems are increasingly evaluated for how well they reduce energy consumption, improve safety for both pedestrians and drivers, and serve as the foundation for a range of Internet of Things (IoT) applications.

WHITEPAPER

Outdoor lighting is an important part of the strategic asset base for cities, municipalities, and large enterprises. But it's a strategic asset that costs money, especially in its energy usage. Optimizing lighting assets depends not only on decisions regarding the luminaires and fixtures themselves, but also about the technologies used to monitor and control large-scale lighting networks.

Echelon Corp., the world's leading control networking platform provider, offers a sophisticated, comprehensive, open standards-based approach to outdoor lighting control that makes it easy and affordable for lighting owners to increase the efficiency, safety, and versatility of their municipal and commercial lighting systems.

Outdoor Lighting Today

According to a 2014 report by market researchers at Northeast Group, more than 280 million streetlights are currently in place globally, with this number expected to grow to nearly 340 million by 2025.

The cumulative costs of these streetlights is staggering. Each streetlight uses 600 to 1,000 kWh/yr of energy, which translates to $70 to $125 in annual electricity costs (assuming an average worldwide energy cost of $0.12/kWh). In addition, each streetlight is responsible for generating 330 to 1,500 kg of CO_2 each year, contributing to global climate change.

Streetlights also cause problems when they are not working properly. At any given time, an estimated 5% to 8% of streetlights are 'daylight burners'—meaning they are on during daylight hours—which burns energy unnecessarily until they are repaired. What's more, any streetlight lamp that fails takes an average of 45 days to get fixed, which leads to customer dissatisfaction as well as a safety risk for as long as the lamp is out.

Adding controls to lighting systems—often in conjunction with conversions to energy-efficient LED lighting, but also without LED conversion—is an emerging best practice. Reasons that greater control is becoming a best practice include:

- **Energy savings** through adaptive lighting and other lighting controls
- **Operational savings and better customer satisfaction** through more efficient maintenance and better scheduling, based on usage and failure analysis and timely access to data
- **New business models** through transitions from building-based to usage-based billing, which can be a benefit in some use cases
- **Additional smart city applications** based on the smart lighting platform

In addition to these broadly applicable rationales for adding control networking to outdoor lighting systems, other geographic- or situation-specific benefits can include:

- **Peak energy management**, such as happens in the East coast U.S. around 7 pm in summer, when buildings are still using air conditioning at the same time that streetlights begin to turn on

- **Improved public safety**, based on research showing that 50% of automobile accidents happen within a three-hour time period at dusk
- **Energy optimization**, which allows cities to add more lights for the same amount of energy usage

The emphasis and value of these benefits varies by geography, country, and other situations, but overall these are the reasons that commercial and municipal lighting owners are moving toward improved control networks.

Saving Energy Through Adaptive Lighting

Most cities allocate and spend between 35% and 40% of their total energy budget on street lighting. Conversions to more energy-efficient lighting sources, such as LEDs, can cut energy expenditures by 30% to 50%. Adding smart controls yields an additional 15% to 30% of energy savings, over and above the contributions of the luminaires themselves.

In developed regions of the world, cities usually reapply the saved energy costs to other parts of the city budget. In developing areas, cities lacking the energy resources to power all the streetlights they need are more likely to view a watt saved as a watt made. Using less energy to power a given number of streetlights frees up energy to deploy more lights or to power other productive assets.

One important way that control networks improve energy efficiency is by enabling adaptive lighting. As its name implies, adaptive lighting is the alteration of the output or duration of lighting in response to demand, real-world lighting conditions, or other parameters.

Adaptive lighting savings result from:

- **Constant lumen output (CLO).** To allow for deterioration over time, most lighting fixtures are overrated initially by 20% to 25%. CLO makes automatic adjustments to a lamp to lower the lumens when a lamp is young, which typically results in 10% less energy savings over the life of a fixture as well as 20% longer lamp life.
- **Lumens on the road (LOR).** Light bulbs come in discreet wattages. Rarely, however, do the conditions of a particular road demand precisely 150W or 250W per fixture. Rounding down risks underlighting the road; rounding up to the nearest wattage means over-lighting and over-paying for energy usage. Using LOR to selectively lower wattage can save 10% in overall energy costs for the streetlighting system.
- **Better scheduling.** Outdoor lighting owners can see an additional 5% in energy savings by using an astronomical clock to switch lights on and off; overriding schedules with a photoelectric (PE) cell that adjusts lumens based on actual ambient light available; and moderating and reporting if PE cells show aberrations during daylight.

- **Programmed and dynamic dimming.** Dimming lights during non-peak hours can lead to 20% energy savings; dynamic dimming—also called 'follow-me' lighting—can save 15% more.

Taken all together, adaptive lighting methodologies contribute about half of the energy savings attributed to the addition of control networks.

Operational Savings Through Better Maintenance

Streetlights that are burned out or broken are more than a nuisance; they can create a safety risk. Traditionally, maintenance crews learned of non-working luminaires through customer complaints or by driving around and looking for lamps that were out.

Control networks for streetlight systems can provide maintenance crews with instant, up-to-the-minute status of all the luminaires in the network and can even anticipate light failures before they happen.

Automatic identification and notification of failed lighting leads to:

- Increased safety, because non-working lamps can be replaced quickly
- Elimination of crews driving around looking for burned-out lamps, which helps reduce carbon dioxide emissions and the general pollution levels of cities
- Fast identification of any unexpected situation on the streetlight grid, including segment failure, cable theft, or power theft
- Reduced maintenance costs

Enabling New Business Models and New Smart City Applications

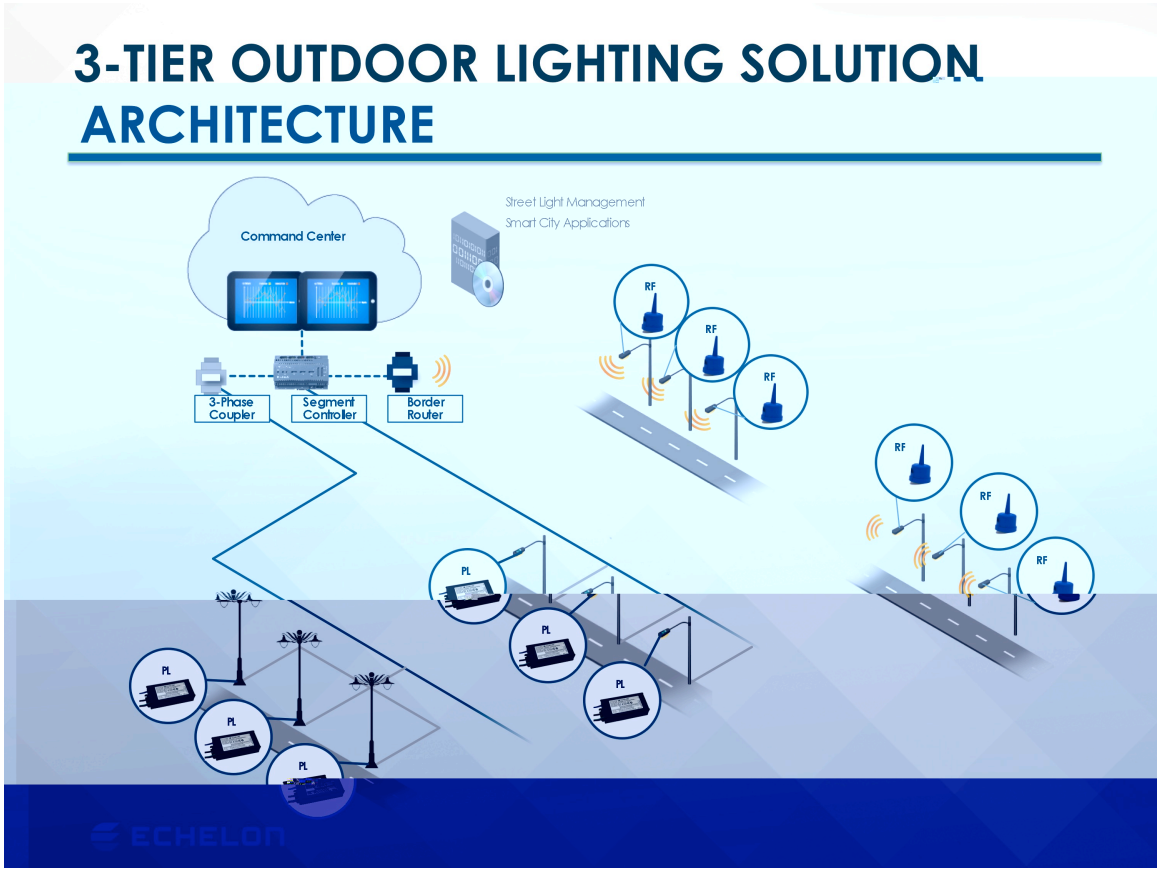
A robust control networking platform can help cities shift to more advantageous business models and serve as the foundation for new smart city applications.

Lighting controls enable cities to measure energy usage on a per-lamp basis. Cities that have a per-pole billing model can opt to switch to a usage-based model, which could help increase revenues (if usage is higher than the per-pole rate) or enable peak-level billing to better manage overall energy usage.

Control networks for outdoor lighting systems—which are 24/7 power and communications grids—can theoretically also be used to control other smart city applications. For example:

- Deploying sensors on the streetlights could allow the monitoring of air or noise pollution, weather, seismic activity, and other conditions in the vicinity of the streetlights.
- Cameras powered by the streetlight circuit could be used for public safety and other video-based applications.
- Streetlighting control networks could control advertising panels, parking spot availability notification, EV charging, and other new city services.

Typical Outdoor Lighting Solution Architecture
The diagram below shows a typical three-tier lighting solution architecture:



On the bottom layer, a number of streetlights are connected to a feeder pillar that is equipped with a segment controller. Segment controllers should have features such as a built-in astronomical clock and scheduler, which can be used to switch the entire segment on and off based on fixed or sunrise/sunset timings for that particular location. Additionally, the segment controller should talk to the energy meter at the feeder pillar, collecting data for the entire segment to be used for billing and analytics.

Each luminaire (lamp post) will be powered by either a wired (typically, power line communications, or PLC) or wireless (usually radio frequency, or RF) lighting controller. The lighting controllers for each luminaire communicate with the segment controller to amass data about energy consumption, lamp status, and other condition, and to send dimming, on/off, and other control commands.

In the middle tier lies the central server for the lighting system, with its secure software, located in a city's data center. Segment controllers communicate remotely with the central server via hard-wired TCP/IP, 3G modem, or GPRS connections.

At the top level of the architecture, end users—i.e., lighting managers or maintenance staff—monitor and control the lighting system via portal accessed using a secure web browser.

To Retrofit or Not to Retrofit?

Outdoor lighting owners can either retrofit existing lamps and add control technologies to the existing network, or replace existing lamps with LED or induction lamps plus a new control network. Each approach has its pros and cons.

Approach 1: Adding controls to existing magnetic ballasts

Benefits of this approach include:

- Ability to identify individual lamp failures
- Up to 20% energy savings
- No more night patrols to check for burned-out or damaged lights
- Compatibility with future deployments
- Full remote control of the network

Weaknesses of this approach include:

- Only 30% to 50% dimming capacity
- Loss of power in aging magnetic ballasts
- Drop in power factor over time

Approach 2: Adding controls to existing electronic ballasts

Benefits of this approach include:

- Ability to identify individual lamp failures plus alarms
- Longer lamp lifetime
- Up to 50% energy savings
- No more night patrols to check for burned-out or damaged lights
- Compatibility with future deployments
- Full remote control of the network

Weaknesses of this approach include:

- Cannot dim more than 50%
- Limited availability
- HPS and MHI are not as efficient as induction and LED

Approach 3: Replacing existing luminaires with LED and induction luminaires

Benefits of this approach include:

- Notification of all alarms
- No lamp changes for 10 to 15 years
- Up to 70% energy savings
- No more night patrols to check for burned-out or damaged lights
- Full remote control of the network

Weaknesses of this approach include:

- More expensive initially, but costs reduce rapidly over time
- Some highway applicability questions

Open Standards: A Critical Success Factor

With all the new outdoor lighting control solutions available, it is difficult to know the best one to choose. Whatever approach a city or municipality takes, it's important not to get locked into a proprietary solution that will limit choice, flexibility, and future options.

Open standards put lighting owners in control of their own destinies. For outdoor lighting control, the ISO 14908 communications standard is key. It supports wired and wireless communications, it allows for multivendor solutions, and it enables the creation of hybrid networks.

Hybrid wired/wireless networks are important for cities that have a mix of lighting needs. For instance, it's impractical to establish RF connections for remote stretches of highway. For other lighting segments, it might be cost-prohibitive to use wired PLC. To achieve 100% coverage, cities need to be able to mix and match their communications media, and ISO 14908 enables this kind of hybrid network.

At the controller level, LonMark International is driving adoption of the ISO 14908 standard for interoperability. Open-standard lamp controllers support various outdoor luminaire controller profiles—e.g., Outdoor Luminaire Controller and Smart Luminaire Controller—and different types of lights.

More than 600 cities worldwide—including Paris, Oslo, Beijing, and Hanoi—have specified ISO 14908 for lighting controls, seeing it as a good investment for greater energy and operating savings, future-proofing, and multivendor choice.

Another emerging standard is TALQ, for enabling one central management system across multiple outdoor lighting networks. Although it is still in development, TALQ promises to provide important gateway standards, including communications via IT standards, common database and data sets, and a single user interface supporting multiple gateway vendors.

Echelon's Outdoor Lighting Control Offerings

Echelon offers a comprehensive range of standards-based outdoor lighting control hardware and software products that fit easily into the ISO 14908 ecosystem.

Echelon products include:

- **Segment Controller:** The Echelon SmartServer 2.0 Controller with PLC and RF border routing manages up to 250 devices and includes an astronomical clock; RTC and scheduler for fixed on/off and dimming; GPRS, 3G, WiMax, and wired

TCP/IP connectivity; SMTP for sending emails; standalone mode for automatic repeating; and digital inputs.

- **RF-PLC Street Light Bridge:** The Echelon CRD 3000 combines multiple power line segments into a single segment, to minimize the number of segment controllers required, increase communications reliability, simplify installation, and maximize both installation flexibility and ROI. The CRD 3000 is ideally suited to use cases where the density of lights per transformer is low.
- **Light Point Controllers:** The Echelon CPD 3000 is a LonMark- and ISO 14908-compliant PL (wired) light point controller. It includes the LonMark Smart luminaire controller profile, works across an input voltage range of 80 VAC to 305 VAC, and dims using 0-10V or PWM, has a switched internal relay for turning lights on and off, and operates within wide temperature and humidity ranges.

  The Echelon CPD 4000 is a LonMark- and ISO 14908-compliant RF (wireless) light point controller. It includes the LonMark Smart luminaire controller profile, works across an input voltage range of 100 VAC to 305 VAC, meters with 2% accuracy, has an integrated photocell, dims using DALI and 0-10V, meets the ANSI 136.41 specification, controls a light of up to 1000 watts, has a switched internal relay for turning lights on and off, and supports 6 LoWPAN, IPv6 stack, and RPL meshing.
- **Central Management Software (CMS):** Available from Echelon in the U.S. and from software partners elsewhere in the world, CMS software includes:
  - **CMS-enabled client software** running on SmartServer hardware is available in four models: low- and high-capacity with internal coupling, and low- and high-capacity with external coupling.
  - **CMS-enabled server software** is offered either as a premise-based license at five levels or as a cloud/SasS model.
  - **Related services** include monitoring, installation support, and yearly upgrades.

Because Echelon's products are standards-based, they interoperate with light point controllers, luminaires, and sensors from a range of third-party suppliers.

Conclusion

Outdoor lighting control is an emerging best practice, and no one has more experience with control networks than Echelon. Echelon offers:

- **A standards-based platform with 100% coverage of both wired and wireless lighting environments.** In fact, Echelon is the only vendor able to support both PLC and RF connectivity technologies, meaning light owners do not have to compromise on achieving full coverage of their lighting control systems. Echelon has been a strong proponent of both the ISO 14908 and LonMark ecosystems.
- **Proven reliability.** Echelon has a track record of more than 600 cities and 2 million lights lit up, and its power line technology has been proven to work in even the harshest environments.

- **Industrial scale.** Among Echelon's successful installations are citywide networks of more than 100,000 lights. Its scalable peer-to-peer architecture and commitment to standards makes it easy for light owners to add of new sensor types.

To find out more about how control networking can lead to better energy efficiency, safety, and ROI from outdoor lighting systems, allow Echelon to create a customized standards-based spec, or contact Echelon to set up a pilot (proof of concept) project.