SmartCitiesCouncil

LIVABILITY | WORKABILITY | SUSTAINABILITY

SMART STREET LIGHTING 101

How advanced street lighting systems can transform cities in remarkable ways

Foreword

Street lights are ubiquitous in cities today. They light downtowns, parks and public gathering places. They light industrial centers and suburban malls. And they light residential neighborhoods. In fact, street lights stretch into almost every nook and cranny in a city where people live or congregate regularly. In the U.S., it is estimated there is one street light for every eight people.

Yet the vast majority of the street lights deployed in the U.S. today – some 45 million – are yesterday's low-efficiency sodium or mercury vapor street lights. And that's true world over. Of the estimated 600 million street lights worldwide, 90% use traditional bulbs.

That's changing, albeit very slowly. Cities and utilities are becoming aware of the benefits of light emitting diode (LED) technology – especially the operational cost savings from LED street lights.

But LEDs and simple control systems that allow dimming and the like just scratch the surface of the potential advantages cities can wring from their lighting assets. Some pioneering cities have recognized that potential and are running pilots that test various "Internet of Things" scenarios. They're installing components that enable street lights to serve as a Wi-Fi hotspot, deliver announcements and host digital signage that can advertise nearby events or provide directions. In other scenarios, sensors are being installed to collect data about air quality, available parking spaces and number of people on the street.

It's clear to me that street lights are destined to become another key tool for making cities smarter, as you'll see for yourself in the pages that follow.

Jesse Berst
Chairman, Smart Cities Council

Table of contents

LEDs brighten the future of lighting costs

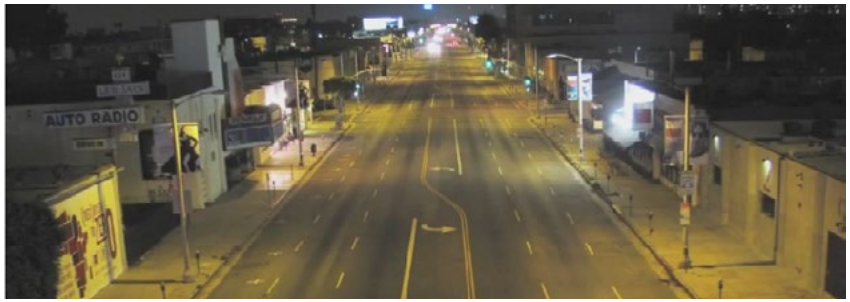
What if there was a way to cut one of your city's biggest expenses in half? LED street lights may allow you to do just that.

Street lights are notoriously expensive, typically consuming about 40% of a city's overall electricity costs. With the threat of crime, turning the lights down or off isn't usually an option. But switching to LED street lights can provide the same amount of lighting at just a fraction of the energy usage.

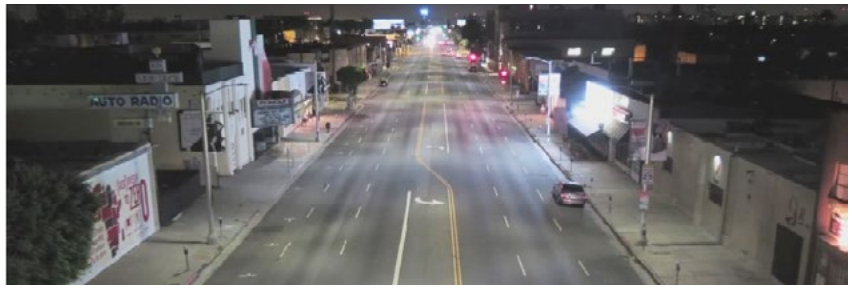
It seems hard to believe, so the U.S. Department of Energy sponsored a lighting demonstration at the University of Florida. Two dancers performed side by side; one was lit with standard halogen lights, the other with LEDs. It's tough to see much difference between them, but there is one big difference: the LEDs used as little as one-tenth of the power.

Already, LEDs are helping cities around the world save money and the environment. Here are a few examples:

- **Los Angeles** reduced its energy use even more than it had forecast after replacing the fixtures in more than 150,000 street lights with LEDs. It cut energy use more than 63%, saving the city $7 million per year in electricity costs.
- **Edmonton, Canada's** street light replacement work has already been completed in 39 neighborhoods, reducing maintenance in addition to energy use.
- **Peterborough, United Kingdom**, replaced 400 low-pressure sodium street lights with new LEDs, cutting its energy use in half and reducing CO_2 emissions by nearly 27 tons per year.
- **Boston** converted 40% of its street lights by the end of 2012, saving the city $2.8 million annually in electricity costs. When factoring in reduced maintenance costs and other savings, Boston expects a payback period under three years.
- **Madrid** is retrofitting 225,000 street lights with energy-efficient lamps, including roughly 84,000 LED lights. The project is expected to cut power consumption by approximately 44%, and those savings will be used to finance the investment.



BEFORE: LA street scene before installation of LED street lights.



AFTER: LA street scene after installation of LED street lights. The LEDs deliver a white, glowing light, and many consider the quality of LED lighting an improvement.

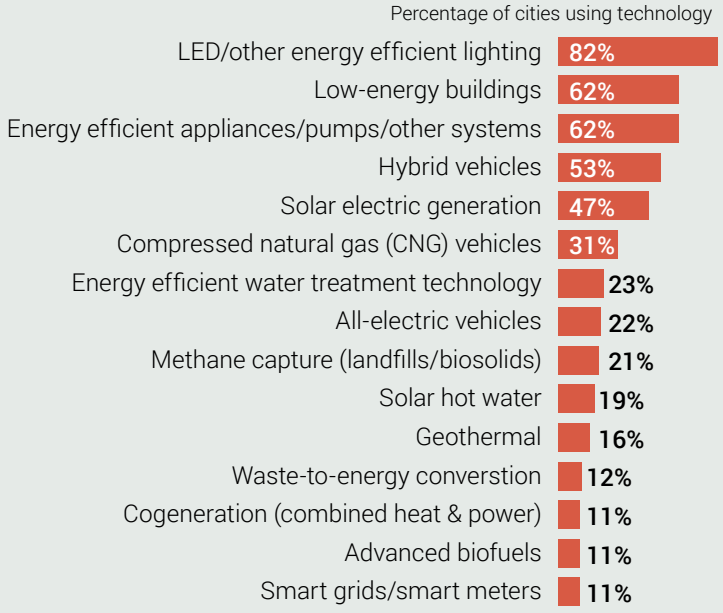
Retrofitting existing street lights with LED lamps typically costs more than traditional street lighting solutions. But given the reduced energy use and longer life spans of LEDs, they can pay for themselves. Typical payback periods range from 4 to 12 years.

How popular are LED street lighting projects?

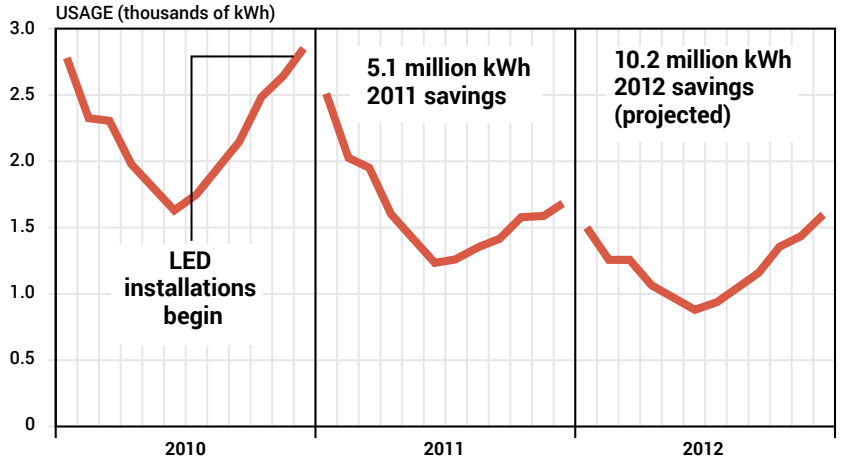
A recent survey of 204 cities by The U.S. Conference of Mayors found that LED or other energy efficient street lighting projects ranked first among energy technologies that have already been deployed by cities. Local and federal resources, most notably EECBG grants, provide the primary sources of funding for these deployments.

As the table below shows, more than four in five cities (82%) made LED or other energy-efficient lighting their top technology deployment.

Technologies already deployed by cities



Boston LED streetlight project



As the graph above shows, street light electricity use in Boston has dropped significantly since LED installations began in late 2010. The city reports that more than 5 million kilowatt hours were saved in 2011, and more than 10 million kWh expected in 2012. At the end of 2012 about 40% of the city's street lights had been converted to LEDs.

The U.S. Department of Energy has a retrofit payback calculator that can help you determine your likely payback period.

CASE STUDY:

Scalable Oakland LEDs work for residential streets and major roadways

The city of Oakland, California has embarked on a project to convert 30,000 high-pressure sodium (HPS) street lights to "scalable" LEDs produced by GE Lighting, a subsidiary of Council partner GE.

Scalable means the LED lamps can deliver a range of lumen outputs. This allows the city to use the system for both the lower light requirements of residential streets and the higher illumination levels appropriate for bigger and busier roadways.

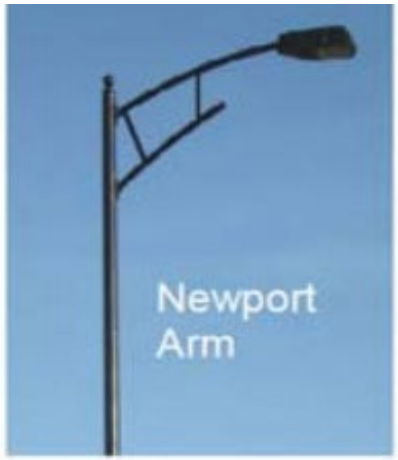
Oakland estimates that the LED retrofit will deliver 40% baseline energy savings compared to its HPS lighting. Moreover, the city

Jean Quan

also expects maintenance savings via the inherent longer life of the LED-based fixtures.

Said former Oakland Mayor Jean Quan: "These lights burn less energy, which means we're reducing our energy bills and our energy use at the same time, and their much longer lifespan also means we're reducing our e-waste footprint."

The project could generate even bigger savings if Oakland opts to connect its LEDs to adaptive controls and a network. The installed system includes controls-ready luminaire, which means down the road Oakland can upgrade its system to allow, for example, dimming the lights during low-traffic periods. That would further slash energy use and also enable automation of maintenance tasks.

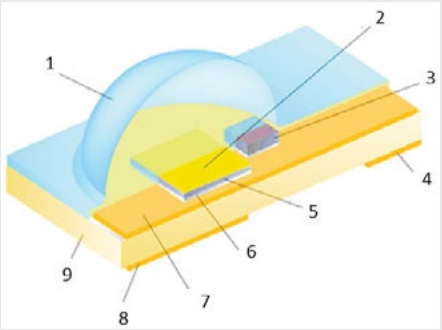


CASE STUDY:

High-tech street lights can have a low-tech look

New street lights don't have to give old neighborhoods a new look. Before launching its street light replacement program, the city of Edmonton, Alberta, ran a pilot project, testing five different LED lights from different manufacturers to find lights with the right look.

The retrofitting work also didn't have to disrupt the character of a neighborhood. In addition to standard plain-looking light stands, a neighborhood can vote to have decorative stands in three styles and colors. In such neighborhoods, residents split the additional cost of the decorative lighting.



1. Silicone Lens
2. Phosphor Plate
3. Transient Voltage Suppressor
4. Cathode
5. LED Chip
6. Bond Layer
7. Metal Interconnect Layer
8. Thermal Bed
9. Ceramic Substrate

About LEDs

The light-emitting diode (LED) light marks a sharp break from the history of illumination. They are essentially electronic devices that have more in common with today's smartphones than the standard light bulb.

Sometimes called solid-state lighting (SSL), LEDs are made of solid-state semiconductors. Because LEDs live in the land of digital technology, you can easily adjust their "dimmability" and in other ways program how they operate. Also – unlike high pressure lamps– they instantly start up.

While LEDs do cost more up front than traditional street lamps, most agree that their efficiency makes them a better investment in the long run. Their low current and low voltage requirements make them last three to four times longer. LEDs also yield twice or three times more light per watt, delivering anywhere from 30% to 70% in annual electricity savings. The energy-conserving benefits of LEDs are in fact so revolutionary that the inventors of LED lamps were awarded the Nobel Prize in Physics in 2014.

Many find the "whiter" quality of LED lighting produces better visibility along streets.

UN declares 2015 the International Year of Light

The role light-based technologies play in spurring sustainable development can help the international community tackle the challenges of the 21st century, Secretary-General Ban Ki-moon said as he unveiled the International Year of Light – the United Nations effort showcasing light's vital contribution to issues related to energy, education, agriculture and health.

Secretary-General Ban Ki-moon

In a message delivered to the Year's opening ceremony held at the UN Educational, Scientific and Cultural Organization's (UNESCO) headquarters in Paris in January, 2015, the Secretary-General explained that light science has already revolutionized medicine, agriculture and energy while today's optical technologies have become the lynchpin to the basic infrastructure of modern communications.

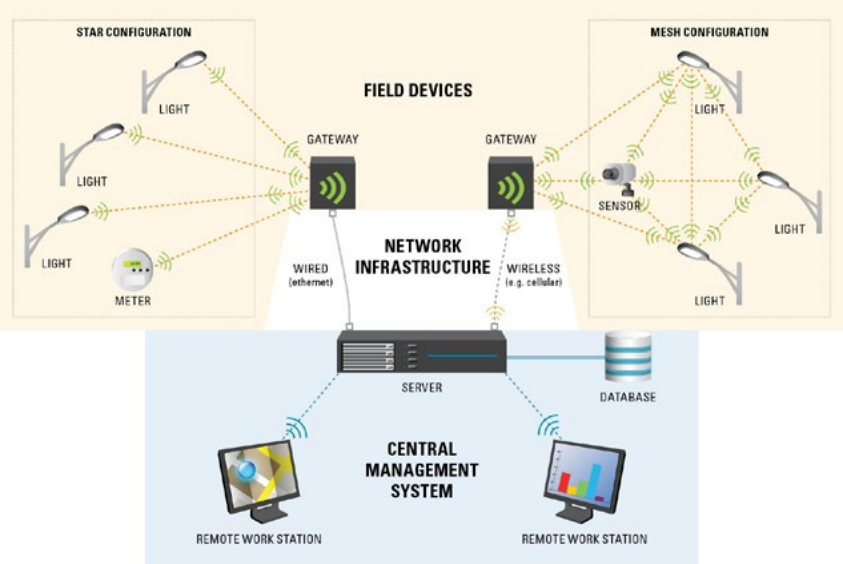
Moreover, he added, by technologically harnessing the power of light, the international community has become better armed in its battle against the most pressing existential threats facing humanity.

"As we strive to end poverty and promote shared prosperity, light technologies can offer practical solutions to global challenges," said Ban.

"They will be particularly important in advancing progress towards the Millennium Development Goals, achieving the future sustainable development goals and addressing climate change."

Control systems make street lights smarter

Because LEDs are essentially electronic devices (see *About LEDs*), you can connect them to control systems that give electric utilities the ability to monitor and regulate light levels in unprecedented ways.



Major components of an outdoor lighting control system.

Given the extra functionality and savings that come from combining LEDs with control systems, some lighting system experts contend that it doesn't make sense to install LED street lights on their own.

Cities can 'tune' their lights

Many street lighting vendors offer control systems that, when combined with a wired or wireless network and remote management software, will link LED street light systems with sensors, switches and dimmers.

Using these controllers, utilities gain the ability to alter the color, intensity and direction of LED light. Cities can "tune" their street lighting to switch on when fog or rain create low daylight levels, or dim when there's too much reflected light or glare from snow cover. Public safety personnel can raise lighting levels, or have LED lights flash, at locations where accidents or emergencies occur. Motion sensors can be programmed to switch on lamps, or raise dimmed lighting levels when cars or pedestrians pass by.

Consider, for example, the city of Eeneind, located in the Netherlands. The city uses a system from Tvilight that dims LEDs to just 20% of power when no one is in the area. When a fixture detects someone, it jumps to full power and tells other lights in the person's path to start to brighten as well to minimize energy usage while maximizing safety.

Boosting efficiency and cost savings

Perhaps even more important, use of LED controllers can take street lighting savings well beyond the energy saved in the light fixtures themselves. The 50% energy savings realized by simply switching to LEDs jumps to 80% energy savings when a controller – with its ability to eliminate over-lighting – is added to the system.

This additional savings, in turn, significantly reduces the return on investment time. A two-and-a-half-year pilot project involving some of the world's largest cities, including New York, London, Hong Kong, Toronto and Sydney, found combining LEDs with smart controls could result in savings of 85%.

Use of controllers can also significantly reduce maintenance

costs. With GE's LightGrid control system, for example, malfunctioning lights – such as burned out lights or lights that burn during the day – trigger immediate service alerts. Technicians only have to visit a light when there's a known problem. Control systems can also record the power use at each light so that a city only pays for the power it uses. This combination of features helped the small town of Tarentum, Penn., population 4,500, save $40,000 per year.

Sorting out network standards

Despite the merits of adding controllers in LED street lighting projects, many cities decide not to include them. Part of the reason is the extra cost.

But another reason, according to a Navigant Research report, is a lack of standardization among the networked control industry players competing in the space. Questions remain over the best networking technology for street light control – power line or radio frequency, and mesh or point-to-multipoint. (*See the sidebar on this page for more on this.*)

CASE STUDY:

LED control systems in Spain and Boston join the Internet of Things

Many street lighting vendors offer their own advanced management systems that monitor and control LED lights. But cities are also looking at independent solutions built around the larger idea of the Internet of Things, the movement to use sensors to collect and analyze a variety of data to improve operations and citizen services. Here are a few examples.

- Council partner IBM is working with two cities in Spain on a project to help operations personnel gather data from devices monitoring street lights, trash containers, parking places and other city elements. The project is built around IBM's Intelligent Operations Center software that provides real-time insight into all city operations and powers the Smart City Center, an integrated command center where data is analyzed and shared.
- Schneider Electric, also a Council partner, is at work on a Boston project that aims to capture and analyze data from the city's 350 facilities, 850 traffic lights, 64,000 street lights and 3,100 city vehicles to help it meet its efficiency and environmental goals. The project makes use of Schneider's StruxureWare web-based tools.

Street light networking technology

The advantages of using programmable controls and dimming features for street lighting is pushing cities toward installing networks and control platforms for street light systems.

City utility managers involved in these projects will want to understand, as with the case of many emerging technology solutions, what's happening in terms of network communication standards being used. Many lighting system manufacturers have gravitated toward two standards to date:

- **Power Line Communications** (PLC) standard enables data to be sent over existing power cables and is popular in a range of smart grid applications.
- **6LoWPAN** is a wireless protocol commonly associated with sensor communications and Internet of Things applications. Both mesh and point-to-multipoint network architectures are used in wireless deployments.

Lighting companies often find they have to support both PLC and 6LoWPAN in city projects. Yet experts believe the industry will ultimately move to adoption of multiple open standards that promote interoperability of network implementations.

Denmark's LED street light showcase

Lighting vendors offer dozens of smart street light options that promise to save cities money as well as collect useful types of data. But how do municipal officials figure out which option is right for them?

A trip to Denmark might help. The country is a leader in municipal LED lighting and has opened the new Danish Outdoor Lighting Lab (DOLL) to primarily help European utility managers peruse the latest LED lighting solutions.

Located in an industrial park outside Copenhagen, the DOLL test facility includes an outdoor "living lab" area with 10 kilometers of streets and paths and park space. Council partner Cisco had a hand in developing it. There vendors can showcase their latest lighting designs and municipal officials can see how well they work in an urban environment before making an investment.

CASE STUDY:

San Diego tunes lights for observatory

Home to an astronomical observatory, the city of San Diego couldn't use just any street lights. Street lights that put out too much light, or the wrong color of light, would interfere with the work at the Palomar Observatory.

For that reason and other considerations, San Diego was the first U.S. city to adopt GE's LightGrid technology. The city can remotely tune each light so it provides light where it's needed and avoid blinding sensitive areas.

The city is installing GE's Evolved LED Avery StreetDreams Post Top street lighting fixtures (seen at right) throughout its Gaslamp Quarter National Historic District.

San Diego forecasts that it will save more than a quarter-million dollars each year through energy savings alone. Maintenance savings are expected to drive that number even higher.

Lighting networks join the smart city infrastructure

Smart LED street lights do not just deliver energy savings, they can also serve cities as a platform for other technologies that improve everything from security to business profitability.

This is because networks established to control and manage LED lighting systems are also capable of doing much more.

Joining the Internet of Things movement, networked street lights give cities the ability to capture data from the world around them through environmental and weather sensors, monitoring devices and video cameras. Here are a few examples.

- In San Diego County, a consortium of utilities and cities have created a pilot project to explore the idea of making street lights a key building block in a smart energy grid. They envision a variety of community-enhancing applications, including holiday lights, chemical sensors and video for enhanced homeland security, and electric vehicle charging stations.
- In the United Kingdom, light stands are seen as potential Wi-Fi access points, helping the government more easily roll out wireless Internet services, especially in rural areas and other places that are hard to serve. In addition to providing an important service, the hotspots could also pay for themselves, with businesses and residents paying for premium access.
- Platforms that enable integration of LED lights with other smart city technologies are springing up around the world. For example, Enel Sole, a subsidiary of Council partner Enel, has developed the Archilede LED lighting system, now deployed in 10 Spanish municipalities. The remotely managed system allows cities to add on video-surveillance systems, Wi-Fi communications, variable message information monitors, and various kinds of sensors. In the U.S., Council partner Silver Spring Networks has likewise established a networking platform that accommodates street lighting along with other smart city solutions.

Collaboration among technology companies is also taking place. For example, Council partners Itron and Cisco are teaming up to develop smart grid solutions that allow transformer meters, street light sensors, solar inverters, EV smart chargers and utility meters to share the same network. Cisco is also working with Sensity Systems to create joint solutions that can convert a city lighting infrastructure into a distributed sensing platform that hosts smart city applications.

Here's a quick look at some specific technologies vendors are combining with LED street lighting systems.

Sensors

Some cities have begun to experiment with adding environmental sensors to their networked street lights. The sensors, coupled with high-bandwidth networking, enable researchers to collect, monitor, analyze and act on real-time information for not only making lighting improvements, but also for public safety, environmental and weather monitoring and parking.

Here are a few types of sensors deployed on street lamps:

- **Air quality sensors.** Data collected from these sensors can provide insights on pollution levels, pollen counts and other public health matters.
- **Image or motion sensors.** These types of sensors can, for example, count pedestrians or cyclists to monitor sidewalk congestion, or even to

triangulate gunshots and alert authorities of other types of crimes.

- **Irradiance sensors.** Cities or utilities that rely on solar energy as part of their energy mix can plant sensors on street light networks to monitor solar intensity in various areas to assist with grid balancing.

CASE STUDY:

Chicago lamp posts become part of data collection infrastructure

New light stands in Chicago are helping city officials there understand traffic patterns and environmental conditions through the use of sensors. Cisco and Qualcomm, both Council partners, are among those involved in the project that will give the city unprecedented insights into air quality, temperature, sound levels and other environmental data. In addition, the sensors on light stands will be able to track traffic by counting the mobile devices in use around them. By being able to detect how many people are in an area and where they are going in real-time, the city gains great insight that it can use to alleviate traffic congestion.

To offset privacy concerns about the data collection effort, the Chicago project makes its data available for review to citizens through the city's Data Portal.

CASE STUDY:

Glasgow's motion detector street lights illuminate problems

Glasgow's adaptive lighting pilot project includes sensors on street lights that can detect noise and movement and other loud disturbances and alert authorities. City officials expect the lights – which can be programmed to flash and to direct emergency crews to a specific site – to speed police response times.

"The intelligent street lighting pilots have the potential to make the city an even safer place for everyone moving about on foot or by bike," city council leader Gordon Matheson told the Evening Times.

As EETimes Europe reports, Glasgow is using the IPv6-based smart city networking platform from Council partner Silver Springs Networks to integrate LED street lights, traffic cameras, and sensors into two adaptive lighting systems in the city center.

Emergency calls and alerts

Some smart street light vendors are offering systems that integrate features that help citizens respond to emergencies. For example, systems from Lumewave and Intellistreets let cities add emergency call buttons that allow someone witnessing a traffic accident or crime to report the event. In the Dutch city of Eindhoven, the street lights can be programed to flash red to warn residents of approaching storms or floods. This same feature might also serve to indicate an emergency evacuation route for traffic in the event of street flooding or natural disasters.

Surveillance cameras

Some lighting vendors now offer smart lighting systems with modules that incorporate surveillance cameras and audio recorders. These tools enable authorities to record and review activity and conversations on city streets, college campuses, airports and other bustling public spaces. Cities often look to deploy cameras in frequently vandalized parks, accident-prone intersections, and high crime neighborhoods.

Amsterdam and Kansas City are working with Cisco on smart city initiatives that include deploying street lighting systems that integrate cameras. San Francisco, Las Vegas and New York are also testing street lighting that has surveillance capabilities.

However, perching surveillance cameras on street lamps doesn't sit well with everyone. Privacy advocates have concerns and want to know how authorities plan to use video recorded conversations, license plates and record video of people.

CASE STUDY:

Ottawa secures park with lamp-mounted cameras

Police patrols had trouble keeping vandalism and illegal drug use in check in Cahill Park in the Canadian city of Ottawa. So the city installed a light pole-mounted surveillance system from Pelco, a company owned by Council partner Schneider Electric.

The system includes an intrusion alarm panel, motion detector, loudspeakers and digital video recorder that activate after the park closes. When the motion detector picks up activity within a defined area, it notifies the city's security operations center and directs the camera to focus on the activity. Operations center personnel can then determine what type of response is required. After the system was up and running, the number of calls to police related to the park fell to zero.

Public announcements and music

As you wander around Chicago's Navy Pier – 50 acres of parks, promenades, gardens, shops, eateries and attractions on Lake Michigan – you might hear soothing music when you pass a street light. And at the Superdome stadium in New Orleans, announcements to football fans entering and exiting the stadium emanate from street lamps.

These are just a few of the ways embedded speakers in network-connected street lights are being used to entertain and inform people passing by. Using network system controls, operators can essentially turn a smart street light fixture into a sound system that broadcasts real-time and recorded audio.

Loudspeaker-equipped light poles can, for example:

- Direct people to available parking at a public event
- Announce weather alerts in beach communities or mountain towns
- Play recorded music at festivals and holidays

Las Vegas is testing a street lighting system that can broadcast sound, and plans to use it mainly to control lighting and play music – and to issue security alerts at a pedestrian mall. "We want to develop more than just the street lighting component. We want to develop an experience for the people who come downtown," said Neil Rohleder with the Public Works Department.

Digital billboards

Some street lights vendors offer systems that have the capability of hosting digital billboards. These LED displays can provide special messaging for events, traffic detours and emergency situations. Cities also have the option to rent out such billboards for advertising purposes, turning street lights into revenue generators.

Financing for smart street lights

Where does municipal funding for LED street light conversions come from? Taxpayers primarily.

While the payback on LED street lighting projects is relatively quick, the upfront costs are often a challenge. In the U.S., a significant funding source has been the Department of Energy's Energy Efficiency and Conservation Block Grant (EECBG) program.

Authorized in 2007, the program became a top funding priority of the 2009 American Recovery and Reinvestment Act, providing $3.2 billion in block grants to cities and other jurisdictions to develop, energy efficiency and conservation projects.

A recent survey of 204 cities by The U.S. Conference of Mayors found that 42 cities used EECBG funds for LED or other energy-efficient street lighting projects.

In Europe, public funding sources are primarily managed at the national level and funding conditions vary among European Union (EU) countries. In general, the funds are not specifically designated for LED street lights, but for projects associated with environmental and energy saving issues.

EU nations can take advantage of the European Energy Efficiency Fund (EEEF), a public-private partnership that provides market-based financing for public sector energy investments, including energy-efficient public outdoor lighting. The main beneficiaries are municipal, local and regional authorities. Another funding source is the European Local ENergy Assistance (ELENA) initiative run by the European Investment Bank (EIB) and funded through Intelligent Energy Europe. Again, local and regional authorities are the targeted recipients. ELANA covers up to 90% of technical assistance costs needed to prepare, implement and finance projects

CASE STUDY:

Operations savings help Boston find funding for LED project

In the face of tight city budgets, finding capital funds for LED street light conversions is often difficult. But discussion of the cost-savings delivered by more energy-efficient lighting can help build the case for conversion.

The city of Boston moved forward on several energy-efficiency initiatives by getting folks in the city's capital and operating budget camps talking. When it becomes clear that an energy-efficient project such as LED lights can substantially reduce the city's operating budget, a willingness to free up capital funds often follows.

"The savings opens up a discussion," said Todd Isherwood, an energy project manager for the city of Boston. "None of my colleagues will move on the budgets unless there is money that can be saved."

CASE STUDY:

Lighting-as-a-service contract lets transit authority deploy LEDs

The Washington Metropolitan Area Transit Authority (WMATA) recently signed a 10-year performance lighting contract that upgrades over 13,000 garage lighting fixtures to LED lights. With this innovative "lighting-as-as-service" model, the transit authority has no upfront costs – which can be a significant barrier to cities and other public entities. The cost of the project is paid for through the estimated $2 million in energy and maintenance savings the LED lighting yields each year. In commenting on the arrangement, a Navigant Research blog notes: "The implications of this business model are significant. WMATA gets a top-of-the-line lighting system essentially free."

Meet the Smart Cities Council

There is no other organization like the Smart Cities Council. We act as a market accelerator and advisor to cities – advocating for the transformation of urban areas into more livable, workable and sustainable communities.

The Council is a coalition of leading technology companies with deep expertise in areas such as energy, water, communications and transportation. We have come together to provide a collaborative, vendor-neutral framework to guide cities through their smart city planning and implementation. We envision a world where technology and intelligent design are harnessed to create smart, sustainable and prosperous cities.

The Smart Cities Readiness Guide, first launched by the Council in November, 2013, is one example of how we are enabling leaders to assess their city's current state of technology and its readiness to become a smart city. We have published other guides that cities are finding helpful. Among them:

- Smart Cities Financing Guide
- Smart Cities Open Data Guide

At SmartCitiesCouncil.com you'll find articles on the latest smart city news and trends, plus a large collection of smart city case studies, white papers, videos and tools. All are available free for the benefit of cities and citizens who want to gain better livability, workability and sustainability.

Council Partners and Advisors

On the pages that follow, we invite you to learn more about our Partners and Advisors– among them are the world's leading smart city practitioners and subject matter experts.

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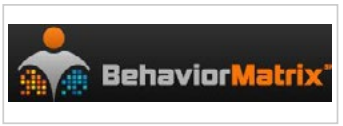

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Institute of Electrical and Electronics Engineers (IEEE)
Institute of Transportation Studies, UC Davis
Inter-American Development Bank
International Electrotechnical Commission (IEC)
International Finance Corporation
International Organization for Standardization (ISO)
International Telecommunication Union (ITU)
International Water Association
Joint Institute for Strategic Energy Analysis
LOCUS: Responsible Real Estate Developers and Investors
Loop Media Hub Ecodistrict
McDonnell Academy Global Energy & Environment Partnership (MAGEEP)
Microgrid Institute
Mike Singh
Mohammed Bin Rushid School of Government of Dubai
Myongji University, Public Administration
National Governors Association
National Renewable Energy Laboratory
Natural Resources Defense Council
New York City Transit Authority
Open Geospatial Consortium
Pacific Northwest National Laboratory
Pedro Ortiz
Pennsylvania Smart Infrastructure Incubator
Pew Charitable Trusts, American Cities Project
Plug-in Hybrid & Electric Vehicle Research Center, UC Davis
Portland Development Commission
Public Financial Management – PFM Group
Research Institute for Water Security, Wuhan University
Rockefeller Institute for Government
San Francisco Municipal Transportation Agency
Sault Ste. Marie Innovation Center
Smart Growth America
Smart Water Networks Forum (SWAN)
Sustainable Streets
Terrapin Bright Green
Teru Talk
The Climate Group
The Nature Conservancy
Transportation and Sustainability Research Ctr, UC Berkeley
U.S. Green Building Council
University of Ontario Institute of Technology
Water Alliance
Waterloo Institute for Sustainable Energy, Univ. of Waterloo
World Bank Urban Advisory Unit