White Paper **WP120001EN** Effective November 2013

"No-Cost" LED street lighting modernization

John J. White, PE, Business Unit Manager, Energy Solutions, Eaton and Council Member for Borough of Seven Fields, Pa.

Improve your municipality's image with LED lighting paid from energy savings

Executive summary

Today, our nation is facing the challenge of balancing municipal budgets while employing efforts to modernize our streetscapes. Revamped street lighting systems can improve aesthetic appeal and community image while enhancing safety and security—but when modern technology is applied, communities can realize even further benefits by increasing energy efficiency, reducing greenhouse gas emissions, and lowering operating costs in the process.

All of these benefits can be accomplished without the use of taxpayer dollars by using an Energy Savings Performance Contract (ESPC), which allows municipalities to pay for energy efficiency upgrades with the savings they produce.

In this paper, we will describe how the latest light-emitting diode (LED) street lighting technology has the potential to achieve greener municipalities that consume substantially less electricity, and require far less maintenance to reduce costs and protect the environment while enhancing lighting levels and quality for residents and visitors.

The paper will also present important financial considerations for embarking on an LED street lighting modernization project by using an ESPC, a viable funding solution that can help municipalities across the nation make high-efficiency LED lighting a reality.

Contents

Description **Page**

The need for a more efficient street lighting solution 2
Benefits of LED street lighting 2
- Reduced energy consumption 2
- Reduced maintenance 2
- Reduced light pollution and wasted energy 2
- Improved light quality 3
- Increased sustainability 3

Important LED street lighting considerations 3
- LED lighting defined 4

Managing an LED street lighting upgrade 4
- ESPC: A purchasing solution that pays back . . . 4

Conclusion 5
About Eaton 5
About the author 5

Powering Business Worldwide

The need for a more efficient street lighting solution

With more than 26 million aging streetlights in the U.S., municipalities have the opportunity to leverage LED lighting to dramatically reduce energy use, electricity and maintenance costs, and improve their streetscapes.

Along with improvements in aesthetics and safety, communities that own their street lighting systems can realize substantial reductions in operating costs by converting older lighting technologies to LEDs. Street lighting is often one of the largest areas of electrical consumption for municipalities, and the application of more efficient technology presents an opportunity to greatly impact the bottom line.

Communities that pay an external utility for street lighting services can also benefit from LED modernization. These communities may find that a significant portion of their lighting tariff rate goes to cover the utility's materials and maintenance costs. By implementing LED technology and owning the fixtures, communities have the opportunity to transition to tariff rates that only charge for electricity, resulting in significant savings over time.

Likewise, communities that lease their street lighting equipment can realize equally substantial cost savings by harnessing the extended life, improved performance, and minimized maintenance that LED technology provides.

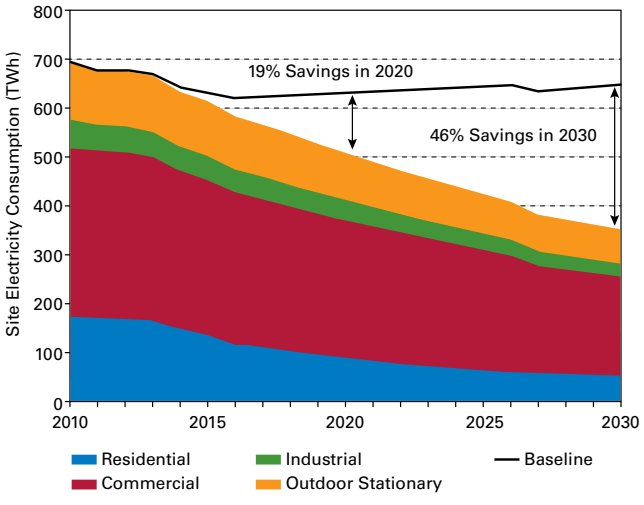
Benefits of LED street lighting

Driven by rising energy costs and growing concern for environmental preservation, LED lighting technology has established itself as a proven alternative to traditional high-intensity discharge (HID) or high-pressure sodium (HPS) lighting. By modernizing aging systems, municipalities can realize:

Reduced energy consumption

LEDs consume a fraction of the electricity typically needed to operate traditional lighting solutions, making them up to 75 percent more efficient. According to the U.S. Department of Energy, the potential benefits of widespread LED adoption for our nation are dramatic. By 2030, solid-state lighting, including LED technology, could potentially reduce national lighting electricity use by nearly half—the annual equivalent to saving:

- 300 terawatt-hours
- $30 billion (in today's dollars)
- Output of 50 1,000-megawatt power plants
- Greenhouse gas emissions equivalent to 40 million cars



Over the 20-year analysis period, spanning 2010–2030, the cumulative energy savings is estimated to total approximately 2,700 terawatt-hours, representing approximately $250 billion at today's energy prices. Assuming the electric power plant generating mix is held constant over the next two decades, these savings would reduce greenhouse gas emissions by 1,800 million metric tons of carbon.

Source: U.S. Department of Energy Solid-state Lighting Program, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl2012_energysavings_factsheet.pdf

Figure 1. Terawatt-Hour Savings Protection through 2030 with LED

Reduced maintenance

It is estimated that LED streetlights operating up to 12 hours a day should last up to 10 years. In contrast, a typical high-pressure sodium lamp has a rated life of 20–24,000 hours, which is the point at which half of the lamps would burn out. This means about half of the lamps would require replacement within 5 years.

LEDs are solid-state devices that utilize semiconductor material instead of a filament or neon gas. Consequently, they can withstand much more demanding environments than traditional solutions—including shock, vibration, and extreme temperatures.

These capabilities contribute to the long operational life of LEDs, which can greatly reduce expenditure on the unsightly distractions of ongoing maintenance with service personnel replacing lamps that burn out frequently.

Reduced light pollution and wasted energy

LEDs are designed to be highly directional and controllable, and can be engineered to provide light only where it is needed in applications such as streets and sidewalks. LEDs also reduce the amount of undesired light, such as the night sky and neighboring properties. Through these capabilities, LED technology can optimize street lighting systems by reducing light pollution and wasted energy by providing accurate, targeted illumination.

Improved light quality

High-quality LED fixtures improve visibility through better color rendering and uniform illumination patterns. Many LED fixtures allow lighting to be dimmed when conditions are appropriate to receive even more cost savings.

LED lighting can be more precisely controlled, minimizing overlit hot spots, and ensuring adequate illumination between luminaries and at the far edges of the space.

Before and after LED implementation images of a parking lot in Georgia.
Source: Georgia Power

Increased sustainability

Most conventional fluorescent, HID, or HPS lamps contain a range of materials, including mercury, which can be damaging to the environment if not disposed of correctly. Because LED lighting solutions contain no toxic materials and are 100 percent recyclable, they can greatly contribute to sustainability goals and an overall reduction of greenhouse gas emissions.

Additionally, the long operational life span of LEDs means that replacement lamps no longer need to be manufactured—saving materials, labor, and energy.

Important LED street lighting considerations

As street lighting is reinvented through modern LED technology, the industry should also re-evaluate the performance indicators used to compare lighting technologies.

Purchasers of LED products, including those for street lighting, often request that manufacturers provide direct lighting replacements based on light output rather than the actual performance at the road surface. This approach can inhibit customers from accurately comparing the savings possible through the implementation of LED lighting.

A common mistake is to make a direct lumen comparison when specifying retrofits. The comparison of lumens provided by typical HID lighting and LED lighting technologies is often inaccurate, due to the enhanced individual aiming and distribution capabilities of LED lighting. With LED technology, lumens are precisely controlled to minimize over-lighting or hot spots, and ensure sufficient lighting throughout the intended distribution area. Light waste is also minimized or eliminated, often without the use of external shielding.

Therefore, when evaluating performance at the road surface, illuminance (foot-candles delivered to the road surface) or luminance (candela/square meter reflected from the road surface) should be used to determine the quality of a roadway lighting design.

Photometric applications or layouts can also be performed to make sure the light levels meet requirements.

The first step for converting an existing street lighting system to LEDs is to evaluate the actual quantity, type, cost of power, maintenance, and performance data of its existing street lighting system. You can then draw on the experiences of other communities and tap the expertise of an industry expert to design a comprehensive street lighting plan catered to your needs. Another important step is to understand the technology associated with LED lighting and how it is defined.

LED LIGHTING DEFINED

- **Lumens** measure light output. The higher the number, the more light emitted
- **Lumens per watt** (lm/W) measure efficiency. The higher the measurement, the more efficient the product
- **Illuminance** (foot-candles or lux) measures light delivered to the roadway surface
- **Luminance** (candela/m^2 or candela/ft^2) measures light reflected from the roadway surface
- **Watts** measure the energy required to light the product. The lower the wattage, the less energy used
- **Correlated color temperature** (CCT) measures light color. "Cool" colors have higher Kelvin temperatures (4500–6000K), and are usually better for visual tasks. "Warm" colors have lower color temperatures (2700–4400K), and are usually better for living spaces
- **Color rendering index** (CRI) measures the ability of a light source to render the true color of an illuminated object. The higher the number, the truer the appearance of the light on objects
- **LED lumen maintenance** measures the percentage of lumen output, as compared to initial output, remaining at a given time
- **Spatial distribution of light** measures light distributions to provide a means of comparison and ensure the lumens produced are directed where they are needed
- **Uniformity of light distribution** by a street lamp can be measured and engineered during the installation process. Uniformity depends on optical properties of the light source, quality of the luminaries' reflectors, and overlapping areas between luminaries. Uniformity of light distribution can be calculated in several ways, including:
  - Average to minimum luminance or luminance ratio
  - Maximum to minimum luminance or luminance ratio
  - Maximum to average luminance or luminance ratio

Managing an LED street lighting upgrade

Today, a wide range of LED manufacturers with varying levels of expertise are available to help municipalities implement an LED street lighting program. To achieve the best results and meet the highest standards in energy-saving projects, experienced manufacturers can provide a range of innovative and reliable lighting solutions, as well as controls and services designed to increase energy efficiency and cost savings over the life of the installation.

For many LED lighting projects, it is beneficial for municipalities to source an accredited energy service company (ESCO). An ESCO is certified by a third-party organization, such as the U.S. Department of Energy (DOE) or the National Association of Energy Service Companies (NAESCO), as having the ability to manage turn-key total energy solutions that include all aspects of key projects, such as needs assessments, installation of systems and equipment, savings verification, financing, and maintenance.

By partnering with an accredited ESCO for a street lighting project, municipalities will receive project planning and detailed commissioning by certified professionals, comprehensive funding support, on-time and on-budget performance, and guaranteed energy and operational savings. Above all, ESCOs provide a single-source responsibility for success with the capability to identify, install, and guarantee performance of these energy-saving projects.

When selecting an ESCO, look for the following:

- NAESCO accreditation
- Turn-key project management capabilities
- Proven success and experience with ESPCs

ESPC: A purchasing solution that pays back

An ESPC allows communities to implement energy savings projects without the need to invest upfront capital costs. Instead, these projects are funded using the resulting energy and operating cost savings to pay for the project over time.

An ESPC is a working relationship between a public agency and an ESCO. The ESCO conducts a comprehensive energy audit and identifies improvements to save energy. In consultation with the public agency, the ESCO designs and constructs a project and arranges the necessary funding. The ESCO guarantees the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. After the contract ends, all additional cost savings are collected by the public agency. Typical contract terms are up to 10-15 years.

The benefits of an ESPC street lighting project include:

- No upfront capital required
- Virtually eliminated streetlight maintenance costs throughout the contract term
- Use of existing energy and maintenance budgets
- Speed of completion—projects typically take less than 12 months from concept introduction to completion
- Meeting or exceeding community energy savings goals
- Positive cash flow throughout financing term
- Guaranteed financial performance or ESCO makes up the difference

The following characteristics can help you determine if your community would be a good candidate for an ESPC street lighting program:

- Desire to improve streetscape
- Limited capital for investment in LED lighting technologies
- Poor lighting quality and/or visibility
- Excessive energy and maintenance costs
- Eligibility for utility rebates and alternative funding sources
- Energy savings and sustainability goals
- Appropriate project size (over 1,000 streetlights) to support the ESCO contracting method

For more information and to see if your project qualifies for an ESPC, visit the Federal Energy Management Program's ESPC website: www.femp.energy.gov/financing/espcs.html.

Conclusion

With more than 26 million aging streetlights in the U.S., municipalities have the opportunity to leverage LED lighting to dramatically reduce energy use, electricity and maintenance costs, and improve their streetscapes.

The seemingly high initial investment of an LED retrofit often intimidates purchasers; however, the benefits of the technology often allow it to pay for itself within 5 years of installation. This return on investment is recovered over time in energy and maintenance cost savings and can result in lasting financial and sustainable benefits.

Although many local governments lack budgets for capital investment in comprehensive renovation projects, ESPC purchasing options through accredited ESCOs enable energy-efficiency projects with no upfront costs, and include guaranteed payback and results.

By tapping an experienced manufacturer with service capabilities or an accredited ESCO, municipalities can simplify a street lighting modernization project from planning stages to installation and maintenance over the life of the system, and complete projects in as little as 12 months from product introduction.

About Eaton

With more than 36 years of proven energy efficiency project experience, Eaton is a NAESCO accredited and DOE qualified ESCO, as well as a single-source provider for ESPC programs—identifying, installing, and guaranteeing payback through energy-efficient performance.

Following the acquisition of Cooper Industries, Eaton's Energy Solutions Group is helping customers improve streetscapes with Eaton's Cooper Lighting light-emitting diode (LED) technology through an ESPC, so municipalities and government agencies can upgrade street lighting with no upfront or out-of-pocket costs. The program provides in-depth audits and reviews of street lighting systems and LED technology to deliver superior illumination, low maintenance, and low cost of ownership for roads and public spaces. To learn more, visit www.eaton.com/energysolutions.

Eaton's electrical business is a global leader with expertise in power distribution and circuit protection, backup power protection, control and automation, lighting and security, structural solutions and wiring devices, solutions for harsh and hazardous environments, and engineering services. Eaton is positioned through its global solutions to answer today's most critical electrical power management challenges.

Eaton is a power management company providing energy-efficient solutions that help our customers effectively manage electrical, hydraulic and mechanical power. Eaton, a global technology leader, acquired Cooper Industries plc in November 2012. The 2012 revenue of the combined companies was $21.8 billion on a pro forma basis. Eaton has approximately 102,000 employees and sells products to customers in more than 175 countries. For more information, visit www.eaton.com.

About the author

John J. White is the Business Unit Manager with Eaton's Energy Solutions Group and a Council Member for the Borough of Seven Fields, PA. White leads a talented management team of nationally recognized energy experts, design engineers, and project managers in delivering optimization services to energy-focused facilities including energy engineering, retro-commissioning, and energy savings performance contracting (ESPC) for a wide range of market segments including government, health care, education, utilities, commercial, industrial, and other institutional facilities. White is a LEED® Accredited Professional, a licensed Professional Engineer, Certified Energy Manager. He holds a Bachelor of Architectural Engineering from Penn State University and an MBA from Johns Hopkins University.

Eaton
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com

Printed in USA
Publication No. WP180002EN / Z14501
November 2013

Powering Business Worldwide