energy efficient TRAFFIC SIGNALS & STREETLIGHTS

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Energy Efficiency in Local Government Operations: The Case for Outdoor Lighting Retrofits

Local governments provide outdoor lighting of many types, including outdoor area lighting (streets, roadways, parking lots, and pedestrian areas) and traffic signals. The electricity used for these lights accounts for a significant portion of a local government's energy bill. Streetlights alone can represent from 5 percent to over 60 percent of a municipal government's energy expenditures, as shown in the table below. In addition, the production of the electricity that powers these lights can be a major source of local government greenhouse gas (GHG) emissions.

Streetlight and Traffic Signal Energy Expenditures and Greenhouse Gas Emissions

Municipality	Cost		GHG Emissions	
	$/yr	% of total energy expenditures	MT/yr	% of total
Swarthmore Borough, Delaware County, Pennsylvania	$53,083	43.9%	133	28.9%
Montgomery Township, Montgomery County, Pennsylvania	$109,706	16.2%	600	13.8%
Haverford Township, Delaware County, Pennsylvania	$434,945	12.9%	1348	8.0%

Source: DVRPC, 2010

Replacing existing streetlights and traffic signals with newer, more energy-efficient lamping can be an important and cost-effective strategy for:

- Reduced energy expenditure
- Reduced maintenance costs
- Improved safety through enhanced visibility
- Decreased light trespass

Prioritizing the most cost-effective energy efficiency projects to undertake is a challenge for many municipalities. However, the time is right for local governments in the DVPRC region to begin making cost-saving investments in energy efficiency. With the recent expiration of rate caps in southeastern Pennsylvania, **the entire DVRPC region is now subject to fluctuating market prices.** For some municipalities, this may mean an increase in electric rates. In addition, this is all happening at a time when many **municipalities are facing severe budget constraints** due to the weak economy and political pressures.

Outdoor Lighting Retrofits

This Municipal Implementation Tool (MIT) provides an overview of the key opportunities for streetlight and traffic signal retrofits, and provides information on where to go for additional resources and funding opportunities. While the scope of this MIT is limited to streetlights and traffic signals, much of the information also applies to the lighting of parking lots, parks, and recreation fields.

Traffic signal projects will be presented first due to the straightforward nature of their implementation. Streetlights will then be discussed in more detail. As shown in the table below, it is important to note that the municipal approach to traffic signals and street lighting retrofit projects will be very different.

Retrofit Type	General Project Considerations Addressed in this MIT
LED Traffic Signals	LED Traffic Signals are viable today. Municipalities should retrofit these as soon as possible.
Energy-Efficient Street Lighting	Technology is emerging. Municipal governments should become familiar with street lighting technologies and project planning process to be ready for a retrofit.

Between 2000 and 2002, Abington Township (Montgomery County, Pennsylvania) replaced all of its incandescent traffic and pedestrian signals with LEDs. The **new signals reduced the township's annual traffic signal energy expenditure from over $130,000 to only $10,000.** Additionally, the LEDs' lower energy use **saved 934 MWh of power** and **reduced the township's GHG emissions by 495 tons per year.**

Additional up-to-date resources on outdoor lighting of all types including traffic signals and streetlights, garage lighting and recreational lighting can be found on DVRPC's Energy-Efficient Traffic Signals and Streetlights Resource Page.

www.dvrpc.org/EnergyClimate/EETrafficStreetLighting

LED Traffic Signals

All municipalities will eventually have to switch to LED traffic signal bulbs. The Energy Policy Act of 2005 requires all traffic signal fixtures to meet ENERGY STAR (2003) power requirements, effectively requiring the use of LED lamps in traffic signal heads. As of today, many municipal governments in our region have yet to switch to these lamps, and PECO estimates that almost 45 percent of traffic signal lamps installed in its territory were still incandescent bulbs as of 2009.

Local governments that have proactively swapped out incandescent traffic signal lamps for LEDs have realized substantial savings, both in energy cost and in operations and maintenance expenditures. **LED traffic signal lamps typically use 80 to 90 percent less energy than the incandescent lamps that they replace.** (Depending on the size and color, incandescent lamps typically use between 70 to 150 W, while LEDs use just 5 to 20 W.) In addition, longer life expectancies of **LED traffic signal lamps can reduce maintenance costs over incandescent technology by approximately 75 percent**, making the payback of a retrofit project as little as one to three years.

Red, yellow, and green traffic signals, pedestrian signals, and flashers are all excellent candidates for LED retrofits

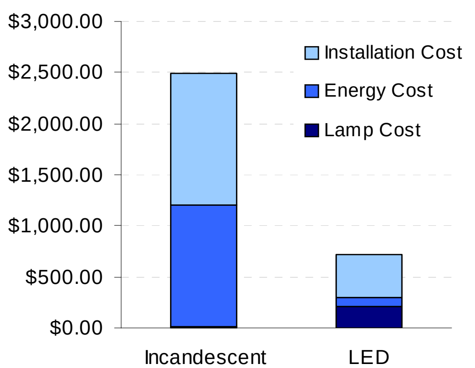
Local governments should act now to switch to LED traffic signals to realize 80 to 90 percent savings in operating and maintenance costs for this portion of their energy bill. See page 6 of this MIT for information on available funding opportunities.

Benefits of LED Traffic Signals

Reduced energy costs: LED traffic signal lamps use 80 to 90 percent less energy than incandescent lamps. Relamping an entire signal (one each of red, yellow, and green) with LEDs would save approximately 540 kWh (for 8” lamps) to 1,200 kWh (for 12” lamps) annually. This would save approximately $70 to $155 per signal annually. Further, LED traffic signals offer significant peak demand savings since they operate 24 hours a day.

Reduced operations and maintenance costs: The life of LED traffic signal lamps is about 50,000 hours, compared to about 8,000 hours for incandescent lamps. Because the lamps last longer, LEDs typically only need to be replaced every five years for red lamps and 10 years for green and yellow, versus two years for incandescent technology. This longer lamp life significantly reduces maintenance costs over time. Some estimates show a 75 percent reduction in these costs.

Seven Year Lifecycle Cost: Incandescent versus LED Traffic Signals



Graph compares three 12” red, yellow and green lamps
Source: DVRPC, 2010

Improved safety and reliability: LED lamps are much brighter than incandescent lamps, with a much lower chance of lamp failure. Because LED traffic signal lamps are made up of a series of smaller individual lights, they fail by partial rather than complete burnout. This allows replacements to be scheduled rather than handled on an emergency basis. Further, because they use so little electricity, LED lamps allow the use of battery backup systems, protecting their functionality in case of a blackout.

Best Practices

Local governments in the region that have installed LED traffic signal lamps shared the following advice on best practices:

- **Relamping:** The energy cost and operation and maintenance (O&M) savings of the original installation of LED traffic signals will pay for relamping costs when LED lamps eventually need to be replaced. However, local governments should factor these costs in upfront to ensure that savings are set aside for this future need. Tools are available to help local governments factor in maintenance savings and replacement costs upfront.

Source: SEDA-COG, 2009

Relamping traffic signals is often conducted using in-house labor

- **Snow accumulation:** Due to the lower operating temperature of LED lamps compared to incandescent technology, LED traffic signals are more likely to accumulate snow on cold winter days. To alleviate snow accumulation on LED traffic signal equipment, some municipalities have installed snow visor equipment. Most note that this is a minor issue.

- **Guaranteed delivery date:** Due to a high demand for LED traffic signal equipment, local governments may want to include a guaranteed delivery date in their contract with the vendor.

LED Traffic Signal Technology

- LED lamps are solid-state diodes.
- Lamp color is determined by elemental composition of LED.
- LED traffic signals are an array of several lights, typically wired so that failure of an individual light results in the failure of only that light and not the whole lamp.
- LED signal lamps are up to four times brighter than incandescent lamps and can more easily be seen in direct sunlight and foggy conditions.
- LEDs draw between 5-30 Watts, depending on size & color.
- The lifetime of an LED lamp is approximately 50,000 hours.

Source: Clinton Climate Initiative's Outdoor Lighting Program, 2010

Resources and Funding Opportunities in the Region

- **PECO Smart Equipment Incentives:** The PECO Smart Ideas℠ programs provide financial incentives to governments and public institutions for energy-efficient street lighting and traffic signal upgrades. Incentives range from $48 to $52 for traffic light signals depending on the size and color, and from $45 to $120 for outdoor and street lighting bulbs. There are also incentives for a wide range of other electrical equipment in local government buildings. Visit www.peco.com/SmartIdeas[1]

- **Bulk purchase of traffic signal equipment** has been shown to lower product cost. In Pennsylvania, local governments have purchased traffic signal equipment through the state's cooperative purchasing program, COSTARS. Local governments purchasing through this program have had success negotiating the contract price with the COSTARS vendor to lower the cost.

More information on these programs, including additional case studies, fact sheets, project calculators, a sample disposal plan for traffic signal lamps and fixtures, product specifications, and other useful project resources can be found on DVRPC's Energy-Efficient Traffic Signals and Streetlights Resource Page:

www.dvrpc.org/EnergyClimate/EETrafficStreetlighting

[1] Follow the link "PECO Smart Equipment Incentives" in the list for business customers. See the text under the heading "For Government, Institutions & Non-profit". A document on outdoor lighting incentives for governments is available at: http://peco.icfi.com/sites/default/files/Lighting%202010%20Govt.pdf

Energy-Efficient Street Lighting

The second area of outdoor lighting that presents opportunities for energy efficiency is street lighting, more broadly referred to as outdoor area lighting, which includes streets, roadways, parking lots, and pedestrian areas. An energy-efficient street lighting project is characterized by more than simply the installation of efficient technology that reduces energy cost; it also leverages the improved lighting quality and control features of emerging technologies, allowing the use of design elements to control the quality of lighting and level of illumination.

Street Lighting Technology Overview

Street lighting technology is rapidly changing due to advances in technology and concerns about energy efficiency. Some new technologies have not yet proven themselves to perform reliably over time in our region and can have higher initial costs than existing technologies. It is important that local governments considering energy-efficient street lighting projects conduct a thorough review of industry best practices and undertake stringent product evaluation based on information from sources other than vendors. The following pages include a primer on energy-efficient street lighting technologies.

Street Lighting Glossary of Terms

- **Ballast** A ballast is a device between the power supply and one or more lamps, providing starting voltage and the appropriate level of electric current for proper lamp operation.
- **Lamp** The industry term for a light bulb.
- **Luminaire** A component of the fixture designed to distribute, filter or transform the light transmitted from one or more lamps.
- **Fixture** Refers to the entire lighting unit consisting of a lamp, ballast, and luminaire.
- **Lumens** The amount of light coming from a light bulb is measured in lumens. Energy efficient bulbs provide relatively high lumens per watt.

Source: DVRPC, 2010

Street Lighting Technology

Incumbent Street Lighting Technologies

Municipal streetlights in the DVRPC region typically use one of two forms of gas-discharge lamps: *high pressure sodium* or *mercury vapor*. A handful of older streetlights use incandescent or metal halide lamps. For example, the street lighting technology distribution within the PECO service territory is provided below.

Street Lighting Technologies Used in PECO Service Territory (2009)		
Mercury Vapor	59,234	53%
High Pressure Sodium	42,533	38%
Incandescent	5,494	5%
Metal Halide	3,581	3%
Note: There are a handful of demonstration projects using LED or induction technologies that are not inclued in this table		

Source: PECO, 2010

Many of these technologies are ideal candidates for energy-efficient retrofit projects. For example, installing or replacing with mercury vapor street lights has been banned in the U.S. Thus, at least 53 percent of the lighting technology currently installed in the PECO service territory will one day have to be retrofitted with new technology.

Emerging Energy-Efficient Technologies

The performance of incumbent streetlights has been improved in a suite of emerging energy-efficient lighting technologies, including **light emitting diodes (LEDs), induction, and a high-efficiency metal halide product named CosmoPolis.** These technologies are described in further detail on pages 17 to 18 of this MIT. These technologies are installed in limited quantity throughout the DVRPC region. Benefits of these technologies are listed below.

- The broad-spectrum light provided by newer street lighting technologies has been demonstrated and publicly affirmed to be **more aesthetically appealing and safer** than incumbent streetlights.
- Emerging energy-efficient streetlights help **lower energy and operating costs** due to more efficient bulbs, and also by allowing for a reduction in the number of poles and fixtures needed to satisfy illumination requirements. Additionally, new technologies also **allow the use of better control and monitoring systems**, which can help manage operating costs.

Further, the improved lighting quality of these more energy-efficient streetlights results in **better visibility through reduced glare**, more even illumination, and enhanced color rendering.

The Retrofit Process

The following “Retrofit Roadmap” shows several common steps for the street lighting retrofit process. By following these steps, municipalities and utilities can capitalize on significant energy and maintenance savings, while avoiding any missteps caused by a conversion to new technologies.

Retrofit Roadmap		
Sequence	**Project Activities**	**Timeline**
Step 1	➢ **Define High-Level Project Goals** Sample goals: reduce lighting related costs, GHG emissions; increase visibility, safety; improve equity of municipal street lighting service. ➢ **Survey Staff Resources** If necessary, consider hiring a consultant who is experienced with street lighting improvement projects.	2 Weeks
Step 2	➢ **Evaluate Existing Equipment** Define opportunities for system improvements.	2 Weeks
Step 3	➢ **Choose Replacement Technologies** Review other projects that have already tested and deployed these technologies.	2 Weeks
Step 4	➢ **Plan & Deploy a Small-Scale Pilot** Evaluate technologies if no other municipalities' test experiences can be leveraged. Utilize lighting engineers in objective evaluation; engage local residents in subjective evaluation. Develop street lighting standards incorporating results of pilot tests.	3-6 Months
Step 5	➢ **Conduct Detailed Economic Analysis (concurrent with step 4)** Assess whether deployment is financially feasible. ➢ **Identify Financing Options** Find resources available to your municipality.	3-6 Months (concurrent)
Step 6	➢ **Craft Business Case for Full-Scale Implementation (using results from steps 4 & 5)**	1 Month
Step 7	➢ **Navigate Local Approvals Process** ➢ **Finalize Finance Plan**	1 Month

Source: Clinton Climate Initiative, 2010

Benefits of Energy-Efficient Street Lighting Projects

Municipalities can save significant operating costs and enhance the quality of street lighting service with an energy-efficient street lighting project. Some of the benefits of an energy-efficient street lighting project are outlined below.

- Efficient energy use: Energy efficient lighting is a function of both the wattage of the lamp and the efficiency of the fixture in which it is housed, with the ultimate goal of providing the necessary amount and quality of lighting to the target area using the least amount of power. Due to the poor optics and color quality of incumbent street lighting technologies, many municipalities are currently over lighting their streets, resulting in lighting levels that are needlessly high. An energy-efficient street lighting project will reduce energy consumption and limit excessive illumination levels. Further, since many new energy-efficient technologies can be dimmed, municipalities can realize increased control over the quantity of light delivered at a particular time.
- Improved lighting quality and visibility: Many newer, more energy-efficient street lighting technologies provide the enhanced visual performance of broad-spectrum light, allowing municipalities to reduce lighting levels to more appropriate levels while providing improved lighting quality. Improved lighting quality and visibility results, combined with better design layout, allow local governments to:
  - Improve uniformity of light distribution and quality of light generated;
  - Reduce over lighting and glare - common street lighting problems that may prevent motorists from seeing other vehicles or pedestrians;
  - Limit light pollution and light trespass nuisance issues by reducing the amount of light that spills into areas where it is not needed or wanted.
- Reduced Maintenance Costs: The longer lives of newer street lighting technology means less time will be spent replacing lamps by municipal or hired maintenance staff. Maintenance cost savings can help make a street lighting project economically viable, especially since the energy savings from using emerging technologies may not be enough to offset the higher initial capital cost of these technologies.

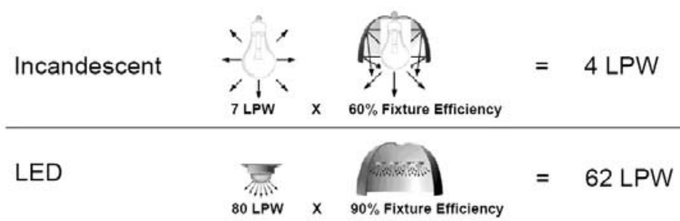
Street Lighting Performance Parameters

Street lighting technologies can be evaluated by a number of performance parameters that measure the **Benefits of Energy-Efficient Street Lighting Projects** outlined on page 10. The following performance parameters should be considered when evaluating new energy-efficient streetlight technologies.

Efficient Energy Use

- **Lamp efficacy (luminous efficacy)** refers to lumens generated per Watt of electricity. Measured as the amount of light generated by a lamp/ballast system (in lumens) divided by the power it uses (in Watts). Energy-efficient street lighting technologies will have high lamp efficacies.
- **Fixture efficiency** stipulates the efficiency with which street light fixtures direct lamp lumens toward the target surface (i.e. roadway or sidewalk).
- **Net efficacy** reflects the efficiency of the system, including lamp and fixture, measured in lumens per Watt (LPW).

Example Net Efficacy Scenario



Source: Efficiency Vermont, 2009

"Energy effectiveness encompasses luminous efficacy of the light source and appropriate power supply in lumens per watt (lm/W), optical efficiency of the luminaire (light fixture), and how well the luminaire delivers light to the target area without casting light in unintended directions. The goal is to provide the necessary illuminance in the target area, with appropriate lighting quality, for the lowest power density."- U.S. DOE, 2008

Control Features

Control features can help maximize the energy efficiency and performance of street lighting. Older control technologies provide the basic ability to time the on/off functionality of streetlights. Newer control systems allow for dimming and remote on/off controls. For example, dimming technology may be used to reduce lighting levels during low-travel times. Control systems are compatible with many lighting technologies — high-pressure sodium, ceramic metal halide, incandescent, induction, and LED can all be dimmed with the appropriate system. However, technologies that do not require warm-up time lend themselves more readily to dimming than those that do.

Improved Lighting Quality and Visibility

- **Color rendering index (CRI)** indicates how colors look under different lighting conditions compared to natural daylight. CRI is measured on a 0 to 100 scale, with 100 representing "perfect" color rendering comparable to daylight. A higher CRI will result in more natural appearance and better recognition of objects. CRI is currently used to measure LEDs, though a new standard thought to better capture LED color rendering is in development. More information can be found at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/color_rendering_index.pdf
- **Correlated color temperature (CCT)** indicates the warmth/coolness of the light that a lamp emits, measured in degrees Kelvin (K). White light with a CCT of 3500 to 4100, for example, provides superior night peripheral vision, and can result in equal or better visibility than other lighting colors, even if it is used at a lower luminosity level.

Correlated Color Temperature (CCT)

Warm white (red/yellow):	2700 to 3000 K
Neutral white:	3500 to 4100 K
Cool white (blue):	5000 to 6500 K

Source: DVRPC, 2010

Reduced Operations and Maintenance Costs

- **Rated lamp life** refers to the amount of time that a lamp technology is expected to provide useful service, commonly measured in hours. Typical HID lamps are considered to be at the end of their useful life when lamps fail, but LED and induction technologies are measured differently. Since LED lamps dim gradually over time, the life of this technology is measured by the percentage of initial lumen output. An LED lamp is considered to be at the end of its useful life when it reaches 70% of initial lumen output. Induction technology is considered to be at the end of its useful life when 50% of lamps are expected to have failed. A longer lamp life will reduce lamp maintenance costs over time as fewer lamps will need to be replaced.
- **Lumen maintenance** is a measure of the degree to which the light output of a lamp is maintained over its service life. High lumen maintenance means that a lamp will operate for a longer period of time before light levels reach minimum illumination standards, thereby reducing lamp replacement costs over time.

The table on the following page summarizes these parameters for each technology.

Technology Overview

LAMPS	ENERGY EFFICIENCY: Lamp Efficacy (lm/W)	ENERGY EFFICIENCY: Fixture Efficacy	ENERGY EFFICIENCY: Net Efficacy (lm/W)	LIGHTING QUALITY: Light Color (Correlated Color Temp. in K)	LIGHTING QUALITY: Color Accuracy (Color Rendering Index, CRI)	OPERATIONS AND MAINTENANCE: Ability to Integrate Dynamic Controls	OPERATIONS AND MAINTENANCE: Rated Lamp Life (Hrs)	OVERVIEW
Incandescent	10-17	60%	Poor 6-10	Warm 2700K	Excellent 100	No	Poor 8,000	Highly energy inefficient, poor lamp life. Incandescent lamps should be retrofitted.
Mercury Vapor (MV)	34-58	30%	Poor 10-17	Cool 6000K	Good <60	No	Fair 28,000	Highly energy inefficient. MV lamps should be retrofitted.
Metal Halide (MH)	61-85	35-40%	Fair 21-34	Warm-Cool 3200-5500K	Excellent 85	Yes[1]	Fair 14,000-18,000	MH lamps are relatively energy efficient. Most have a poor lamp life, and are expensive to maintain.
High Pressure Sodium (HPS)	70-150	45%	Good 32-68	Warm 2220K	Poor 22	Yes[1]	Fair 20,000-24,000	Relatively energy efficient. Efficiency gains may be lost by over-lighting to mitigate poor color accuracy.
HE Ceramic Metal Halide	95-120	60-80%	Excellent 57-96	Warm-Cool 3200-5500K	Excellent 96	Yes	Good 24,000-30,000	20%-50% more energy efficient than HPS lamps. Very long lamp life.
LED	50-100	60-90%	Excellent 30-90	Cool 5200-6200K	Excellent >70	Yes	Excellent[2] >50,000	30%-50% more energy efficient than many HPS lamps. Superior lamp life.
Induction	60-80	60-80%	Good 36-64	Warm-Cool 2500-6500K	Excellent >70	Yes	Excellent[2] >100,000	40%-60% more energy efficient than HPS. Superior lamp life.

Source: Clinton Climate Initiative / DVRPC, 2010

1 Dimmable using a ballast, may require a new fixture

2 LED is generally considered to be at end of its useful life when it reaches 70% of initial lumen output, or L70. Induction is considered to be at the end of its useful life when 50% of the lamps are expected to have failed.

Project Planning Considerations

Identifying the most appropriate street lighting technology for a retrofit project requires consideration of a number of project planning issues, including:

Cash-Flow Analysis – New street lighting technologies will have a higher capital cost than incumbent technologies, though the reduction of maintenance and energy costs from new technologies will likely result in a lower overall lifecycle cost. Municipalities choosing to design and install an energy-efficient street lighting project should conduct a detailed cash-flow analysis in order to assess the lifecycle cost associated with installing new street lighting technology. An economic analysis should identify initial project costs, project funding, and expected energy and maintenance cost savings to determine the overall life-cycle cost of the project. In order to make a project cost effective today, municipalities may have to leverage additional sources of funding through grants, loans, and rebates. DVRPC's Energy-Efficient Streetlight and Traffic Signals webpage has a number of tools available to develop a cash-flow analysis.
See: www.dvrpc.org/EnergyClimate/EETrafficStreetLighting

- Capital costs - Energy-efficient street lighting technologies often have a higher initial cost than currently installed technology, with simple payback periods of six to ten years. An increasing number of financing options for municipal street lighting projects are available to defray initial capital costs.
- Utility costs
  - Energy cost – Many utility companies do not currently bill for new street lighting technologies, which requires the customer to negotiate a new rate based upon either lamp wattage of the installed technology or the metered wattage if a meter is installed. When the cost of electricity is low, the retrofit of street lighting technology may only be cost-effective for highly inefficient technologies (such as mercury vapor). However, electricity costs are predicted to rise throughout the region, as rate caps expire in Pennsylvania.
  - Utility tariff structure - Whether street lighting equipment is owned or operated by a municipality, local utility companies will typically charge a flat tariff for individual streetlights or groups of streetlights. The structure of the tariff will vary by utility, but may include energy, operations and maintenance costs, and an interconnection "tap-in" fee. *In some cases, the cost of energy will be exceeded by these other tariff costs.*

Project Planning Considerations Continued

- Cost savings
    - Reduced energy cost - In addition to energy cost savings realized through reduced wattage, your analysis should include expected utility rate escalation costs over time to fully capture the value of your street lighting investment.
    - Operation and maintenance cost savings - Municipalities that maintain their own streetlights can recoup the labor cost savings associated with longer lamp lives. Additionally, optimal project design will result in the fewest number of poles and fixtures, not only ensuring that light goes only where it is needed, but also minimizing maintenance costs.

Project Funding – Because financing is one of the most commonly cited obstacles to street lighting retrofit projects, project funding should be identified early in the planning process. Municipalities should consider funding from a variety of sources:

- Government sources - Governments at the national, state and local level in many cases provide funding, often at low- or no- cost of capital, for energy saving projects through a variety of programs.
- Utility sources - Utilities are another common source of finance for energy saving projects. For lighting retrofit projects, the rebates are often provided on the basis of kWh saved, or as a flat rebate per fixture installed. Through Pennsylvania's Act 129 program, PECO provides a cash rebate for each fixture installed that is more efficient than existing technology.
- Debt financing - Municipalities typically have access to tax-exempt finance, which lowers the overall cost of borrowing. Tax-exempt sources of debt include:
    - Tax-exempt municipal lease
    - Bonds
    - Structured debt
- Third-party financing - There is an emerging group of investors interested in placing equity in energy-efficiency projects, recognizing potential for strong and solid returns on investment.

Internal sources of capital - Internal sources of capital, when available, may represent the fastest and most cost effective way for a municipality to finance a project. Internal capital can be deployed quickly, minimizing the cost of delay, and may often be deployed without financing or transaction costs.

Best Practices

- Local governments should conduct a thorough review of emerging technologies and the funding available for implementation. While these emerging technologies provide a range of benefits, it is critical that municipal governments be cautious in selecting quality products given the market's emerging state.
- While in some cases the initial purchase cost of an energy-efficient lighting retrofit may be higher than that of the technology it replaces, these increased project costs can be financed or supported through a variety of project finance options; these options are best explored in the context of a project cash-flow analysis.
- Several local governments in the region are considering a switch to energy-efficient streetlights. Communities should, where possible, share resources and best practices. A number of local governments have, for example, already drafted bid specifications for LED traffic signals and are in the process of developing these bids for street lights. To be connected with other local governments considering these projects, contact DVRPC's Office of Energy and Climate Change Initiatives.

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Two utility company employees install LED streetlights.

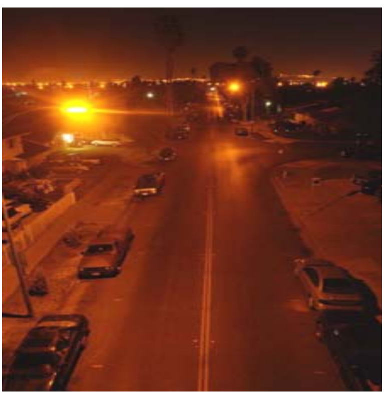
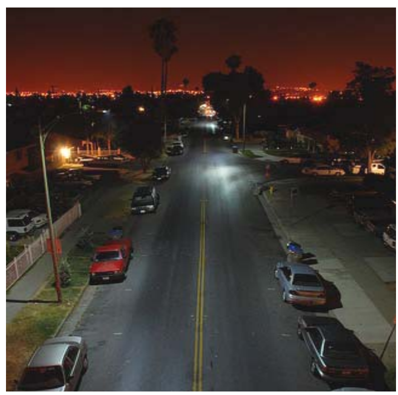
Source: PG&E 2010

Primer on New Energy-Efficient Street Lighting Technology

Light Emitting Diodes

There are multiple benefits of light-emitting diodes (LED). LEDs can achieve 50 percent or more savings over high-pressure sodium technology. LED lamp life, defined as when the lamp reaches 70 percent of original lumen output, is estimated at greater than 50,000 hours of operation – approximately 12 to 20 years. Additional benefits of LEDs include instant on/off, the ability to integrate dynamic controls, and improved color rendition and enhanced visibility.

Common incumbent technologies such as MH and HPS technologies continue to improve incrementally, whereas LED technology is improving very rapidly in terms of luminous efficacy, color quality, optical design, thermal management, and cost.

High pressure sodium lamps (left) versus LED technology (right)
Source: City of San Jose

Early adopters should be aware of the potential issues associated with LEDs because it is an emerging technology and product quality can vary significantly among manufacturers. Issues include thermal and electrical design weaknesses that can lead to reduced lamp lifetime, as well as inconsistencies with color temperature and optics.

> LED retrofit products intended to be used in existing HID luminaires have an additional challenge of adequately rejecting heat generated in the fixture, and thereby may result in reduced performance and expected lifetime. The best performing products to date have been designed as LED luminaires from the ground up, thus enabling optimization of heat rejection by using the luminaire body itself as the heat sink.

Induction Lighting

Induction fixtures have been used in street lighting applications for more than two decades. Induction technology offers energy-efficiency improvements of up to 40 percent over HPS, very long lamp lives with more than 50 percent of lamps still expected to be operable at 100,000 hours. Additional benefits similar to LEDs include instant on/off, the ability to integrate dynamic controls, improved color rendition, and enhanced visibility.

However, unlike the emerging nature of LED technology, induction technology has likely already reached its optimal performance quality. While induction's performance and cost is competitive with LED technology currently, LEDs are expected to outpace induction technology in the future.

Issues associated with induction technology for street lighting technology remain. Induction lamps produce lumens in 360 degrees, which is beneficial in applications where a high degree of vertical foot-candles is desired, such as a tunnel. Street lighting, however, presents a somewhat rectangular target directly beneath the pole, and a significant amount of reflectors and secondary optics are required to control the output and reduce the amounts of stray light headed in unwanted directions. Additional issues with induction are similar to LED and include the risk of inadequate or improper thermal management, leading to premature product failure.

High pressure sodium lamps (left) versus induction technology (right)
Source: City of Portland Bureau of Transportation

High-Efficiency Ceramic Metal Halide

Another energy-efficient street lighting technology used among municipal governments is a new ceramic metal halide product called CosmoPolis. These lamps offer 20 to 40 percent savings over HPS, the ability to integrate dynamic controls and, improved color rendition and enhanced visibility. One drawback of these lamps, however, is a shorter lifespan, at 24,000 to 30,000 hours.

Outdoor Area Lighting

The use of energy efficient lighting technology, particularly LED lighting, in outdoor area lighting applications such as parking lots, garages, and outdoor recreational areas can provide energy and maintenance cost savings and lighting quality improvements over incumbent lighting. As with street lighting, high intensity discharge lamps currently dominate parking and recreational lighting. More local governments are turning to emerging technologies, particularly LEDs to realize cost savings from reduced energy consumption and lower maintenance needs.

The image above shows high pressure sodium (HPS) lamps on the right and LED lamps on the left. HPS lamps have hot spots of light near the source. LEDs, however, demonstrate an improved and uniform lighting quality distribution due to the directional characteristics of the lamps. Source: Beta Lighting

LED Parking Garage Lighting Retrofit in West Chester Borough

West Chester Borough (Chester County, Pennsylvania) recently replaced 195 of the 250W high pressure sodium lamps in their Bicentennial Parking Garage with 69W LED lights for a total project cost of $127,322.50. Through the Pennsylvania Department of Environmental Protection's Conservation Works! program, West Chester received a grant to cover 50% of total project costs, resulting in an out of pocket cost to the borough of $63,661.25. West Chester realized a 43% reduction in energy use that saved $1,210 per month in energy costs. With energy cost savings alone, the township will pay back its investment costs in less than four and a half years.

Light Emitting Diodes – Standards and Specifications

Like incumbent lighting technologies, LED lamps and luminaires must meet certain industry standards designed to ensure safety and performance. To accommodate LEDs, some existing standards and test procedures are being modified, while in other cases, new standards have been developed. More information on LED standards can be found within the U.S. DOE's Solid State Lighting LED Measurements webpage:
http://www1.eere.energy.gov/buildings/ssl/measurement.html

Two important standards relating to the energy efficiency and lifespan of LED lamps are the Illuminating Engineering Society of North America (IESNA) LM 79-08 and LM 80-08.

LM 79-08 (LED lamp efficacy and efficiency of lumens hitting the target area) *IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products*: Specifies procedures for measuring total luminous flux, electrical power, luminous efficacy, and chromaticity of LED luminaires and replacement lamp products.

LM 80-08 (LED lifespan) *IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources:* Specifies procedures for determining lumen maintenance of LEDs and LED modules (but not luminaires) related to effective useful life of the product.

DOE Checklist for LED products

- Ask for photometric test reports based on the IESNA LM-79-08 test procedure.
- Ask about warranty; 3 to 5 years is reasonable for outdoor luminaires.
- Check ingress protection (IP) ratings, and choose an appropriate rating for the intended application.
- Ask for operating temperature information and how this data relates to luminaire efficacy and lumen depreciation.
- Check color temperature for suitability in the intended application.
- Assess glare, preferably with the luminaire at intended mounting height and under typical nighttime viewing conditions, compared to incumbent technology.
- Evaluate economic payback, based on applicable energy, equipment, maintenance, and control costs for the site.

Source: http://www1.eere.energy.gov/buildings/ssl/outdoor_checklist.html

Energy Efficient LED Streetlights in Warwick Township

Warwick Township (Bucks County, Pennsylvania) is home to approximately 14,700 residents. In 2009, Warwick began a project to replace 272 existing mercury vapor and high pressure sodium streetlights with energy-efficient LED lights. Total project costs for Warwick were estimated at approximately $246,850; $211,011 of these costs were covered by a grant received through the Pennsylvania Department of Environmental Protection's Conservation Works! program. As a result of this partial retrofit of their street lighting system, Warwick Township has realized a 52% reduction in township's annual electric consumption, or 49,392 kWh annually. At current electric rates, these reductions have resulted in energy cost savings of $1,570 annually, for a total savings of $180,832 over the estimated 20-year life of the lamps. Warwick Township also anticipates reductions in maintenance costs due to the longer lifespan of LED fixtures. The environmental benefits of the retrofit project include an annual reduction of 137,325 lbs of CO_2e.

Resources

DVRPC Office of Energy and Climate Change provides additional resources on street lighting, including case studies, fact sheets, product specifications, and other useful project resources, including **DVRPC's new Municipal Streetlight Analysis Tool** to help municipalities analyze the cost effectiveness of various streetlight retrofit scenarios. These resources and the information provided in this MIT can be found on **DVRPC's Energy-Efficient Traffic Signals and Streetlights Resource Page.** DVRPC will continue to update this webpage as information becomes available.

www.dvrpc.org/EnergyClimate/EETrafficStreetLighting

Clinton Climate Initiative Outdoor Lighting Program (OLP) has assembled the following whitepaper that provides a more thorough overview of street lighting technology. The OLP has worked with cities around the world to improve the energy efficiency of street and traffic light systems by advising on project management, purchasing, financing, and technology.

http://www.clintonfoundation.org/files/CCI_whitepaper_lighting_2010.pdf

Resources Continued

LED technology resources from the U.S. Department of Energy

U.S. DOE Municipal Solid-State Street Lighting Consortium collects, analyzes, and shares technical information and experiences related to LED street and area lighting demonstrations. The Consortium will also provide an objective resource for evaluating new products on the market intended for street lighting applications.
http://www1.eere.energy.gov/buildings/ssl/consortium.html

U.S. DOE CALiPER Program provides independent laboratory assessments of LED lighting products to verify manufacturer performance claims.
www1.eere.energy.gov/buildings/ssl/caliper.html

U.S. DOE Gateway Demonstration Program is an independent pilot test evaluation program funded by DOE and executed by Pacific Northwest National Lab. DOE GATEWAY Demonstrations showcase high-performance LED products in a variety of commercial and residential applications. Demonstration results provide real-world experience and data on product performance and cost effectiveness. DOE shares the results of completed GATEWAY demonstration projects in reports that include analysis of data collected, projected energy savings, payback analysis, and user feedback.
www1.eere.energy.gov/buildings/ssl/gatewaydemos.html

U.S. DOE Solid-State Lighting: Outdoor Area Lighting webpage for up-to-date information on the basics of LED lighting technology for outdoor area applications.
http://www1.eere.energy.gov/buildings/ssl/outdoor.html

Rebates and project financing through local electric distribution companies. Municipalities should contact their local electric distribution company for available funding or financing for energy efficient street lighting projects. The following programs provide incentives to municipalities for energy efficient outdoor lighting projects:

PECO Smart Equipment Incentives: The PECO Smart Ideas℠ programs provide financial incentives to governments and public institutions for energy efficient street lighting and traffic signal upgrades.
www.peco.com/SmartIdeas

New Jersey Clean Energy Program: New Jersey municipalities that own their streetlights are eligible for incentives for LED and induction streetlight technology through New Jersey's Clean Energy Program. These "Prescriptive Lighting Incentives" are available through this program's SmartStart Buildings program. More information on these incentives can be found at: http://www.njcleanenergy.com/ .

ABOUT DVRPC

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals and the public with a common vision of making a great region even greater. Shaping the way we live, work and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region – leading the way to a better future.

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