RESPONSIBLE PURCHASING **GUIDE**

LED Exit Signs, Street Lights, and Traffic Signals

RPN
Responsible Purchasing Network
Center for a New American Dream

About this Guide

The Responsible Purchasing Guide for LED Exit Signs, Street Lights, and Traffic Signals is published by the Responsible Purchasing Network in print, as a PDF file, and on the web. Print and PDF copies are available to the public for purchase. The online edition includes additional resources available to members of the Responsible Purchasing Network, including: searchable product listings, multiple policy and specification samples, comparisons of standards, and related documents. Visit www.ResponsiblePurchasing.org to purchase a copy or to access the members-only web-based edition of the Guide.

About the Responsible Purchasing Network

The Responsible Purchasing Network (RPN) was founded in 2005 as the first national network of procurement-related professionals dedicated to socially and environmentally responsible purchasing. RPN is a program of the Center for a New American Dream (www.newdream.org) and guided by a volunteer Steering Committee of leading procurement stakeholders from government, industry, educational institutions, standards setting organizations, and non-profit advocacy organizations.

Acknowledgements

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This Guide is designed to help organizations maximize the benefits of retrofitting exit signs, street lights and traffic signals with high efficiency LED bulbs.

Social and Environmental Issues

LED lighting helps reduce the greenhouse gas emissions that cause climate change because they replace far more energy intensive light bulbs. About 39 percent of the energy consumed in the U.S. is used to generate electricity (EPA 2009). In 2007, electricity production consumed 36 percent of the fossil fuels used in the U.S. and generated 42 percent of fossil fuel-based CO_2 emissions (EPA 2009). This fossil fuel-based electricity contributes to global warming. Coal-burning power plants emit ground level ozone, causing smog, which causes respiratory problems in humans; as well as mercury, which causes nervous system and heart damage as well as cancer. LEDs reduce energy consumption-related environmental impacts compared to incandescent lamps commonly used to illuminate exit signs and traffic signals. LED street lights have a lesser impact because they are mercury-free, they do not emit UV light, and they are less prone to “light pollution” (illuminating the night sky) than conventional high pressure sodium (HPS) and metal halide (MH) street lights because their light beams are highly directional.

Best Practices

Assemble a lighting working group comprised of staff members representing various departments: environment, purchasing, energy, public safety, transportation, maintenance, facilities and buildings. Gather and review existing policies to address energy efficiency, and add language pertaining to lighting, or adopt a new lighting policy. Establish a baseline of expenses and equipment, then determine costs associated with energy-efficient retrofits. Establish goals for the project and implement your lighting retrofit plan. Inform and train stakeholders on your new technology, improve practices, report progress, and reward successes.

Cost, Quality and Supply

LEDs can significantly reduce the electricity consumed for exit signs, street lights, and traffic signals; up to 95%, 75%, and 93% when compared with incandescent exit signs, high-pressure sodium (HPS) or metal halide (MH) street lights, and incandescent traffic signals, respectively. Currently, the higher purchase price of LEDs is recouped in about two to four years, on average, for exit signs and traffic signals; and four to twenty years for street lights. These savings are achieved through energy savings and decreased maintenance costs. As the price of LEDs drops, the payback will be even quicker. Additionally, LEDs require minimal maintenance because LED Traffic Signals and Street Lights last from 60,000 to more than 100,000 hours, which is 7-11 years of continuous use, whereas LED Exit Signs can last 50,000-200,000 hours.

Policies

The Policies section contains a model LED purchasing policy, developed by RPN and the Green Purchasing Institute. You will also find a chart of additional policies and their relevance to each of the products in this guide.

Specifications

RPN Model Specifications for Exit Signs and Traffic Signals, as well as the recommended model specification for Street Lights contain contract language that can be used to procure the most energy-efficient lighting solutions available. Other sample specifications are provided. Bid solicitations should include maximum wattage requirements, minimum rated life and lumen standards, a take-back provision, and a product warranty.

Standards

Currently, there are no third party environmental leadership standards for exit signs, traffic signals, or street lights. The US Department of Energy is developing an ENERGY STAR Standard for Solid-State Lighting, which is scheduled for launch in late 2009. We recommend seeking products in the top 25 percentile of energy efficiency and pilot testing them before purchasing large quantities. Each of the products in this guide can be used to earn USGBC credits toward LEED certifications.

Products

See the Products section for a list of recommended products that meet energy efficiency and other criteria in the RPN Model Specifications.

Calculator

See the Calculator section for a variety of tools to help you quantify cost and energy savings from LED products.

Definitions

The definitions section provides a glossary of terms used throughout the Guide.

Credits and Endnotes

The credits and endnotes section lists the people responsible for writing, reviewing, and editing this Guide along with a listing of sources referenced.

Conventional exit signs, street lights and traffic signals all consume considerably more electricity than currently available light-emitting diode (LED) alternatives.

ENERGY AND GLOBAL WARMING

About 39 percent of the energy consumed in the U.S. is used to generate electricity. In 2007, electricity production consumed 36 percent of the fossil fuels used in the U.S. and generated 42 percent of fossil fuel-based CO_2 emissions (EPA 2009). This fossil fuel-based electricity contributes to global warming. Coal-burning power plants also emit ground level ozone, causing smog, which causes respiratory problems in humans. The demand for coal is expected to double by 2030 (IPCC 2007).

EXIT SIGNS

Incandescent exit signs typically contain two 15- or 20-watt bulbs (e.g., 15T6 and 20T6.5 lamps) that draw 30-40 watts in total, whereas LED exit signs consume as little as less than one watt and no more than 10 watts. Since exit signs are lit year-round, 24 hours per day, each LED exit sign retrofit can save about 300 kWh, preventing the release of half a ton of CO_2e annually (US EPA, ENERGY STAR, undated). Replacing incandescent-lit exit signs with new LED signs or retrofitting existing signs to use LED lamps is one of the easiest and most cost-effective energy efficiency retrofits available to public and commercial facilities.

A smaller number of exit signs in the U.S. are lit with linear or compact fluorescent lamps. While fluorescent-lit exit signs are more energy-efficient than incandescent-lit models, they still use up to 10 times more energy than LED-lit exit signs.

STREET LIGHTING

Conventional street lights contain high-pressure sodium (HPS) or Metal Halide (MH) lamps which typically use 70 to 400 watts of electricity, while LED-lit street lights consume about 35-75% less energy to achieve equivalent visibility. Other high-wattage lamps found in street lights include incandescent light bulbs (the least efficient), halogen, and low-pressure sodium lamps. Based on a pilot study in San Francisco, the US Department of Energy and a local power company estimated that, "if the nationwide stock of installed HPS roadway luminaires were replaced with LED luminaires…8.1 TWh [trillion watt-hours] of total annual energy savings could be achieved, with a corresponding 5.7 million metric tons of CO_2 emissions abate" (ES 2008), equivalent to taking 934,066 cars off the road for a year (EPA Clean Energy Calculator).

TRAFFIC SIGNALS

Like exit signs, traffic signals operate all day, every day. There are approximately 260,000 signalized intersections in the U.S., employing between 3 million and 4.5 million traffic signals. Many traffic signal modules still use incandescent light bulbs which last up to two years and consume about 1,314 kWh per year. LED bulbs last 10 or more years with continuous use and consume 80-90 percent less energy. A single LED traffic module conversion has the potential to save 1,266 kWh per year. Converting all traffic signals in America from incandescent to LED bulbs would save an estimated 3 billion kWh of electricity annually (CEE 2007). Seventy percent of the savings (approximately 2 billion kWh) would come from just replacing the red signals. Another 900 million kWh could be saved by converting all green signals, and 61 million kWh could be saved by the conversion of yellow signals (ACEEE 1998).

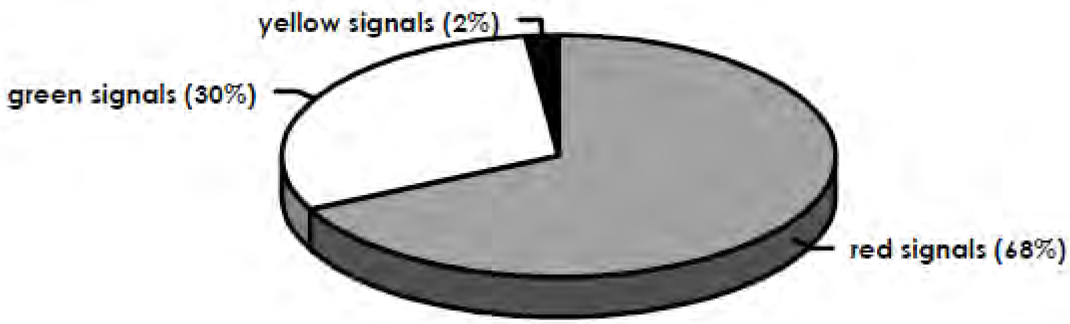

Figure 1: Percentage of total potential energy savings by traffic signal color. Red signals have the greatest duty cycle (55%) and red LEDs have the lowest wattage of all traffic signal colors. Therefore, retrofitting red signals represents the greatest potential energy savings of any color.

If all traffic signals in the US were converted to LEDs, the carbon dioxide emissions savings would be equivalent to taking more than 350,000 cars off the road.[1] Some regions, such as EPA Region 8 (Colorado, Montana, Utah, North Dakota, South Dakota and Wyoming) have an even greater opportunity to reduce emissions because their carbon emissions factors are higher than the national average due to a greater number of coal power plants (DOE 2002).

Hazardous Substances, Health, and Safety

Many conventional lighting products contain hazardous substances such as mercury that may be harmful to human and animal health. LEDs do not contain these hazardous substances. It is important that lights used in critical functions such as exit signs, street lamps and traffic signals maintain their lighting, but incandescent and HPS bulbs can become partially or fully unlit far more frequently than LEDs, and thus cause avoidable safety hazards. LEDs can also improve visibility (see Quality section), which can reduce traffic accidents.

Exit Signs

Incandescent signs, which contain lamps that typically have a rated life of 500 to 5,000 hours, are likely to become partially or fully unlit more often than LED exit signs, creating safety hazards for building occupants during emergencies, and risking fines by fire marshals. Frequent bulb-changing poses occupational risks for workers who must climb ladders to remove fragile glass bulbs that may contain lead solder in their bases. Lead is a known neurotoxin and causes learning and developmental disabilities.Fluorescent lamps used to light exit signs generally have a rated life of 5,000 to 10,000 hours, which is longer than most incandescent lamps but still far shorter than LEDs, which can last 25 years or more (GPI, 2009). Replacing fluorescent

[1] Calculated using emissions factors of 11,450 pounds CO_2/year per passenger car (EPA 2000), the US average of 0.676 metric tons CO_2/MWh (DOE, 2007), and 3 billion kWh /year savings estimate (CEE 2007).

lamps can expose workers and occupants to mercury, a persistent and bioaccumulative toxic chemical known to cause damage to the brain, nervous system and heart of humans and animals. Mercury can be released during lamp manufacture, storage, transportation, installation, recycling or disposal. Few companies use low-mercury dosing technology for the manufacture of exit sign products. As a result, each lamp used in a fluorescent lit exit sign can have more mercury than a modern fluorescent lamp used in typical overhead office lighting. For example, according to data provided by Sylvania, their modern 46-inch T5s typically contain up to 2.5 mg of mercury, while their 6- to 9-inch preheat fluorescent exit sign lamps contain up to 15 mg of mercury (Sylvania, 2009).

Some self-luminescent (photoluminescent "glow in the dark," tritium, and battery-powered) exit signs produce sufficient light to meet fire codes without relying on external power sources. Tritium is a radioactive material that, in large doses, can lead to cancer, genetic defects and fetal development problems. It requires special handling and disposal. Battery-powered signs have no back-up power supply, and can therefore put building occupants at risk if the batteries are dead during an emergency. See the Cost, Quality, and Supply section for more detail on self-luminescent exit signs.

In addition to solely battery-powered exit signs, some others contain back-up batteries to ensure the sign remains lit in the event of electric power failure. The batteries used typically contain a nickel-cadmium alloy or lead-acid technology. Both cadmium and lead are persistent and toxic heavy metals that concentrate in the food chain if they are released into the environment during manufacture or disposal.

STREET LIGHTING

Street lights are commonly equipped with HPS, metal halide, and, increasingly, induction lamps (a type of "cold cathode" fluorescent). These lamps contain mercury, a persistent and bioaccumulative toxic (PBT) chemical known to cause damage to the brain, nervous system and heart of humans and animals. Mercury can be released when these products are manufactured or when these fragile items break during storage, transportation, installation, recycling or disposal.

Light Pollution

Conventional street lighting often directs light upward into the night sky or to where it is not needed, which causes light pollution and hampers work at astronomy observatories. According to the International Dark Sky Association (IDA), street lights – particularly those that are unshielded – can interfere with wildlife behavioral instincts. The IDA cites numerous studies documenting that light pollution can discourage sea turtles from migrating to shore, disrupting their nesting practices, as well as the mating and migration practices of other types of wildlife. The State of Florida DOT replaced its street lights with LED discs embedded into the roadway in order to significantly reduce light pollution along a beach where turtles nest (Khan & Broadwell 2009).

While LEDs emit white light, they reduce light pollution because their light beams are highly directional and controlled – meaning that it can be precisely pointed or controlled in the desired direction with little light being emitted elsewhere. According to the City of Ann Arbor, "LEDs give us more control over what we light (streets and sidewalks) and what we don't (the night sky). This makes for easier compliance with the Dark

Skies Initiative, which aims to reduce light pollution and its associated wildlife impacts" (Ann Arbor, no date).

Poor light quality
Conventional high-pressure sodium (HPS) and low-pressure sodium (LPS) street lamps emit bright yellow light. While these technologies are often chosen because they reduce "white light pollution," they can present a safety risk by making it difficult for the public to accurately identify vehicles and people in the event of a crime.

Unlit lamps
HPS lamps (except for non-cycling models) present a safety risk when they cycle, or "flicker" on-and-off near the end of their life. Cycling lamps cause confusion for maintenance personnel who come to service a street light outage and find that the light appears to be functioning. This confusion may mean that lamps are not always replaced when necessary, risking unlit streets. Cycling HPS lamps also damage the ballast of the lamps, increasing maintenance costs.

Traffic Signals

Incandescent bulbs use tungsten filaments that burn at extremely hot temperatures. LEDs avoid these filaments and instead produce light by applying electricity to a junction between an electron-rich and an electron-deficient material. The principal material used for red and yellow LED-lit signals is Aluminum, Indium, and Gallium Phosphate (AlInGaP). Green (and blue, but blue is not used for traffic signals) LED-lit signals principally use a substrate of Indium and Gallium Nitride (InGaN). Older LED-lit signals may contain Aluminum Gallium Arsenide (AlGaAs). The dust from these materials is an irritant to the eyes, skin and lungs, posing a potential health hazard during LED manufacturing. Other toxic chemicals, including solvents, may be used to manufacture LED semiconductor materials.

End-of-Life Management

Incandescent light bulbs enter the waste stream at a much faster rate than LEDs because LEDs have much longer lifecycles. Many conventional lighting products -particularly fluorescents- must be handled as hazardous substances at the end of their useful life. Incandescent lamps often contain lead solder in their base, which workers can be exposed to at various stages in the product lifecycle. In contrast, LED lamps are mercury-free and most are devoid of lead solder as well.

Exit Signs

A typical incandescent exit sign bulb lasts just 500-5000 hours (about 1-6 months) and must be replaced about twice per year. In comparison, red and green LED exit sign lamps typically have a rated life of 50,000 to 200,000 hours, i.e. 6-25 years, and some come with a 25-year warranty. At the very minimum, 10 incandescent bulbs are disposed of for every one LED required to light the same exit sign.

Some exit signs contain batteries, which should be collected and recycled. Rechargeable batteries can be recycled free-of-charge using programs such as *Rechargeable Battery Recycling Corporation's Call2Recycle Program* (www.rbrc.org).

Street Lighting

Most street lights utilize mercury-containing lamps (e.g. HPS, metal halide and induction), which generally must be recycled or handled as hazardous waste.

Traffic Signals

A typical incandescent traffic signal lamp has a rated life of about 8,000 hours, which is much shorter than LED traffic signal lights, as noted elsewhere in this Guide.

LED exit signs, street lights, and traffic signals should be recycled when done with their useful lives. Many manufacturers have take-back programs whereby LEDs can be returned for recycling instead of thrown away. See the RPN model specifications for sample take-back provisions available to purchasers.

Lighting retrofits can be treated as an integrated, coordinated project, or tackled one by one. The best practices below include general practices for lighting retrofits (which might also include retrofitting incandescent office lighting with fluorescent or LED bulbs) and specific practices related to Exit Signs, Street Lighting, and Traffic Signals.

1. **Assemble a Lighting Working Group**
   Designate a staff leader or form a working group comprised of staff from departments affected by lighting, such as: environment, purchasing and facilities, energy, public safety, parks and recreation, ports and airports, and other interested stakeholders such as non-governmental organizations (NGOs) and other community groups. This team should design and implement a plan, setting goals, tracking, reporting on successes, and addressing challenges.

   > *Street Lights* - The US Department of Energy has established the Municipal Solid-State Street Lighting Consortium, which is a coordinated effort among interested cities, power providers, and government entities to minimize duplication of effort and spread associated risk across multiple locations. Learn more about the Consortium at:
   > http://www1.eere.energy.gov/buildings/ssl/gatewaydemos_consortium.html

2. **Adopt Policy**
   Gather and review any existing policies and guidelines related to this initiative, such as those addressing energy efficiency, recycling, green purchasing, hazardous substances, building codes and guidelines, and sustainability and climate action plans. Look for opportunities to add or improve the language dealing with lighting, if needed.

   Then adopt or reference policy and/or guidelines that clearly outline your organization's commitment to environmentally preferable lighting, including energy efficiency, toxics reduction and waste prevention, safety, maintenance, light pollution, and end-of-life management. The commitment should explicitly address exit signs, street lighting, and traffic signals but may cover other types of lighting, and might be part of a broader energy efficiency or green purchasing policy, sustainability or climate action plan, or building code guidance document.

   See the RPN Model Policy in the Policies section of this Guide.

3. **Measure and Monitor**
   Conduct an inventory of current products and practices and calculate baseline costs and impacts. Fill in the **baseline worksheets** in Addendum I, II, and III to survey the types and quantities of exit signs, street lights, and traffic signals in place and their potential alternatives.

   Use the worksheets in Addendum I, II, and III to measure and monitor costs and other impacts.

A. Create a spreadsheet or database to track the following:
  - Type of exit sign, street light, or traffic signal
    - Incandescent, fluorescent, Light-Emitting Capacitor (LEC)-lit, LED-lit, HPS, MH, Photoluminescent, Tritium, etc…
    - 8 inch or 12 inch traffic signal
    - Green, red or yellow traffic signal
    - Ball, Arrow, Pedestrian Hand, Pedestrian Walking Man
    - Wattage requirements
    - Battery-powered (include battery type)
    - Other features
  - The location of each light or exit sign
  - Number of each lighting type in use
  - Last replacement date or annual replacement rate
  - Rated life of existing lamp and replacement
  - Replacement and disposal costs
  - Maintenance Costs, including labor
  - Annual Energy Costs

This information may be available by surveying staff, reviewing historical purchasing data, or by auditing sites directly. Vendors may be required or requested to provide reports with some or all of this data.

B. Using this baseline information, calculate total cost of ownership of current exit signs, street lights, and traffic signals- See Addendum I, II, and III for **baseline and replacement/retrofit worksheets.** Compare this information with that of the new or retrofitted lighting. Track the following data:

  - Quantity purchased, installed and recycled per year;
  - Expenditures on disposal, recycling, installation, and maintenance;
  - Labor required for installation and maintenance;
  - Energy consumed per year and its source (e.g. coal-fired, renewable, etc)
    - Refer to energy utility bills and the EPA eGrid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html)
  - Emissions related to energy consumption (e.g. greenhouse gases and mercury)
  - Solid and hazardous waste generated
  - Light quality
  - Safety impacts

4. Project Costs and Benefits

Calculate and compare the total cost of ownership of baseline products and their alternatives.

Many LED suppliers, as well as energy savings companies (ESCOs), will finance the initial costs of LED retrofit projects in exchange for a portion of the energy savings associated with the project. There may be government-funded energy efficiency grants or loans or utility incentives available to help offset the cost of converting traditional exit signs, street lights, or traffic signals to LEDs (or other energy-saving technologies). At least 30 cities have requested over $104 million in federal stimulus funds, combined, to help them replace their existing street lights with more-efficient LED luminaries (Keen 2009). The City of San Jose is using $2 million in energy efficiency stimulus funding to help pay for the installation of 1,500 LED street lamps (Rosenthal & Barringer 2009).

5. **Establish Goals**
Set goals based on policy, construct timeline, and develop implementation plan for replacing all incandescent, fluorescent and tritium exit signs in the organization's facilities. Similarly, set goals and timelines for replacing incandescent traffic signals and incandescent, fluorescent, or HID (mercury vapor lamps, metal halide lamps, and high-pressure sodium lamps) street lamps with LEDs.

6. **Draft and Implement a Retrofit Plan**
Develop an implementation plan for replacing exit signs, street lights and/or traffic signals with high efficiency LEDs (or for exit signs, LECs). Integrate the plan into other transportation, green building renovation or lighting retrofit projects as appropriate.

   Create a procurement process for LED lighting products and/or services based on the Model Specifications in this Guide (See the Policy and Specifications sections). If you decide it is necessary, conduct pilot tests of new or untested LED or other environmentally preferable lighting products.

   The City of Los Angeles Bureau of Street Lighting has developed a set of *LED Equipment Evaluation Procedures* that can serve as a model for other communities and utilities to follow to ensure that high-performance LED street lighting products are chosen. These procedures include the following steps:

   - Issue a Request for Equipment Evaluation. This establishes minimum requirements vendors must meet before field testing equipment.
   - Review Engineering and Technical Documentation. Consider inviting vendors in to make presentation about their products.
   - Sample Equipment. Require vendors to provide a free sample of their equipment meeting your specifications.
   - Perform Laboratory Evaluation. Let vendors know that the equipment may be opened during the evaluation and therefore may not be returned in original condition. Test equipment for electrical performance, mechanical performance, aesthetics, and ease of maintenance.
   - Perform Field Evaluation. Only test products in the field that pass laboratory evaluation. Install fixture with monitoring device to enable performance data to be collected remotely. Make sure field tests protect public safety and are representative of typical street lighting applications.
   - Conduct Field Investigations. Take illumination readings and check the condition of the LED fixture (LABSL 2009a)

The pilot test may also collect comments from the local community on neighborhood lighting quality, and evaluate light output, operating temperature, and actual energy consumption, as was done in the Ann Arbor, Michigan pilot.

7. **Inform and Train Stakeholders**

   Inform Staff

- Share policies and plans with staff, particularly electricians, facility and energy managers, custodial supervisors, purchasers, specifiers, architects, and other affected staff.
  - Convene staff to explain the environmental and cost benefits of the changes and to answer questions. Emphasize ways the new products will reduce maintenance and improve worker safety.
  - Post relevant policies, procedures, approved product lists, audit forms, and other resources to the organization's EPP webpage and appropriate staff websites.
- Train purchasing staff on how, when, and what to order.
  - Ensure that purchasers and specifiers know which LEDs products to order and which lighting products are no longer being used.
  - Train contract users on the availability of energy-efficient products offered on organizational price agreements. Inform them about utility rebates, stimulus funding and other financial incentives.
- Train facilities and maintenance staff. Incorporate guidance into your purchasing and facility construction and operations manuals.
  - Share resources with facilities staff, such as the Exit Sign, Street Light and Traffic Signal Audit Form. See Addendum I, II, and III.
  - Ask suppliers to train staff (especially electricians) about how to install any new or retrofit products approved for use.
  - Post the names of staff qualified to install new or retrofit products.
  - Train those staff to properly handle and recycle any hazardous waste such as existing fluorescent, HPS, MH and mercury vapor lights and batteries, and inform them of useful programs such as RBRC's recycling program for rechargeable batteries and any vendor or manufacturer take-back services offered on your contracts.
  - Ensure that only specially trained staff handle and dispose of tritium exit signs since they are radioactive.
- Monitor and enforce policies and practices.
  - Inform staff of the deadlines for auditing, replacing and retrofitting your lights and check in with them periodically about their progress and obstacles.

Inform Suppliers

- Share lighting policies and procedures with vendors in writing and, if feasible, in face-to-face meetings in order to answer questions.
- Communicate to suppliers which lighting products it now prefers and which it prohibits.
- Work with vendors to set up an auto-substitution program that will automatically recommend or supply LED replacement lamps when contract users order incandescent exit signs or traffic lights.
- Provide a reporting template to suppliers to collect sales data on products they sell to you.
- Contact end-users to make sure they are selling LEDs whenever practical.
- Use a Qualified Products List that meets or exceeds the specifications in this Guide. Improve Practices

8. **Iterate practices that reduce energy and improve exit sign, street light and traffic signal performance.**

- *Exit Signs* - The most important step facility operators can take is to replace existing incandescent exit signs with LED- or LEC-lit exit signs or upgrade them using an LED exit sign kit.

- *Exit Signs* - Consider taking additional precautions to improve building exiting (or egress) procedures, which are required by law in some municipalities. For example, following the September 11th attack on the World Trade Center, the City of New York adopted new regulations requiring exit signs to have larger 8-inch letters with a 1" stroke (rather than 6 inch letters with a ¾-inch stroke, which is the minimum required by law) along with metal housings (rather than thermoplastic). You can find these by ordering NYC-Approved exit signs. NYC also requires egress pathways such as stairwells to be labeled with photoluminescent "glow-in-the-dark" markings, which are generally placed on or near the floor. Consider the use of Braille (tactile) and other ADA-approved exit sign and egress marking products.

- *Street Lights* - Light pollution can be minimized by decreasing the amount of light emitted from each fixture, directing light to the desired surface, shielding the top and the sides of each fixture to minimize glare, planting trees between the light source and sensitive ecological areas, and using motion sensors and dimmers to reduce light output when it is not needed.

- *Street Lights* - Reduce maintenance costs and improve safety and performance by installing and utilizing "intelligent management systems" that utilize GPS and other technologies to remotely monitor outages so that maintenance staff can be immediately deployed), balance light output, and even collect data on traffic patterns to improve traffic flow. These systems also reduce energy consumption through dimming and other energy management strategies.

- *Traffic Signals* - Optimize traffic signal timing to reduce idling. Use fiber optic cables instead of copper wire. Fiber optics transmit digital information via light pulses that allow each signal to communicate with a central computer that can determine when a malfunction occurs and automatically notifies a technician. It can also allow city engineers to easily time the lights through intersections, cutting down on emissions-producing idling at red lights. Fiber optic cables carry more upfront costs than copper, but are expected to reduce maintenance costs over the long-term.

- *Traffic Signals* - Conduct independent lab testing to verify the actual lifespan of LED traffic signals. Then establish a maintenance program for monitoring and on-going replacement of LED signals based on lab evaluation. The program should mandate annual budget requirements and a multi-year fiscal planning lifecycle. Benefits of a set replacement program are a uniform and known budget and lesser likelihood of complete signal failure.

- *Traffic Signals* - Install battery backup systems. When power outages occur, even LED traffic lights become non-functioning. This results in accidents and traffic congestion. To alleviate this problem, many local jurisdictions installed battery backup systems. These systems would be installed in the traffic control cabinet located at the intersection or in an adjacent cabinet. When a power outage occurs, the battery backup system works in conjunction with the controller to either operate the red signal in flash mode or to operate all the signals in the fully functional mode.

9. **Report Progress**
   Publish an annual report detailing successes and challenges encountered by your lighting team, comparing current year energy consumption, replacement and disposal costs, and environmental impacts, with the baseline data collected at the start of the program. This can be a stand-alone report or part of a broader energy efficiency or sustainability report for the organization as a whole. Share the report with institutional leaders and with the stakeholders engaged in the program, in order to acknowledge good work and identify obstacles. Share the report, or a summary of the report, with media and the public.

10. **Reward Success**
   Acknowledge members of the lighting team and any others who helped the program succeed. Consider extending contract expiration dates with vendors that are particularly helpful in implementing this initiative. Publish a case study showcasing the institution's success and documenting the cost savings and environmental impacts of the program.

LED replacements for exit signs, street lights, and traffic signals are readily available, offer comparable quality and additional safety features, compared to conventional alternatives, and have lower total costs.

Cost

Although LEDs typically have a much higher purchase price, they are far more energy-efficient and longer lasting than their conventional counterparts which leads to lower total costs when factoring in electricity savings and reduced maintenance and disposal costs.

When compared to available alternatives, LED street lights are often the best cost value choice because they offer improved visibility; low power consumption, infrequent maintenance and replacement, and, unlike HPS and other mercury-containing street lights, contain no hazardous components that require special handling.

Exit Sign Costs

Currently, LEDs are far more cost-efficient than incandescents and fluorescents. They are available in a variety of styles (including matrix, stencil and edge-lit models) and price levels. In the short term, it may be cheaper to continue using incandescent bulbs in existing incandescent-lit exit signs. However, it is more cost-effective to replace existing incandescent and fluorescent-lit exit signs with new LED or LEC-lit exit signs or to upgrade them using an LED retrofit kit.

Fixture Type	Typical Wattage (watts)	Bulb Life (years)	Annual Bulb + Labor Cost	Purchase + Install Cost	Annual Energy Cost	1st Year Cost	10th Year Cost Savings
Incandescent (existing)	40	0.5	$26	$0	$39	$65	-
Fluorescent (existing)	11	1.0	$27	$0	$11	$38	$269
LED (new installation)	2	10+	$0	$20 + $25	$2	$47	$581

Figure 2. Cost of Exit Signs: Incandescent vs. Fluorescent vs. LED
Extracted from:
http://www.responsiblepurchasing.org/purchasing_guides/led/cost_quality_supply/EnergyEfficiencyLEDExitSigns.pdf

Street Light Costs

Converting HPS, MH, mercury vapor, or incandescent street lights to LEDs incurs a capital cost, but this can be recouped over the lifetime of the lights. LEDs have an estimated lifetime five times longer than conventional HPS or MH lamps, and energy savings of 35% or more. These efficiencies mean that payback periods for LED street lights can currently be as low as 4.4 years (Ann Arbor, no date). Because the entire street luminaire (see below), not just the lamp, is typically replaced when converting conventional street lights to LED street lights, jurisdictions may reduce installation time and avoid warranty issues. More expensive LED street lighting systems include dimmers or motion sensors, but can dramatically decrease costs by reducing energy consumption and maintenance costs even further.

Use the following to calculate Total Cost of Ownership:

- price of the initial luminaire installation
- replacement costs of bulbs of ballasts (for HPS and MH street lighting systems) versus any replacement LED arrays or drivers
- maintenance costs (mostly labor)
- electricity consumption
- disposal costs (including mercury recovery for HPS, metal halide or mercury vapor lamps)

Other economic benefits of LED street lamps include safety factors such as improved visibility, lower susceptibility to vandalism, and reduced likelihood of bulb outage, which can increase the potential for accidents.

Installation Costs

A significant barrier to greater use of LED street lights is their high upfront cost – especially when an existing fixture would not otherwise be replaced. Using LED street lights for new lighting projects has a much shorter payback period than do retrofit projects.

Most LED retrofit projects involve replacement of the luminaire, which includes the fixture, LED array, and driver. Installers in Raleigh, North Carolina observed that "[LED] fixtures were lighter, more balanced, and easy to install" (PE 2009). Alternatively, some companies offer LED street lighting retrofit kits that can be installed without replacing the entire fixture. One such product offered by OSRAM Opto SemiConductors is designed to replace a 250-watt HPS street lamp with a 40-watt LED array, yielding an 85% energy savings (OSRAM 2008). However, purchasers are advised to be wary of LED retrofit products from less established manufacturers, since existing fixtures that are not designed for LED bulb use can exacerbate heating problems, leading to shorter bulb lifespan and quicker lumen depreciation.

In LED street light pilot programs, costs for LED arrays vary widely according to vendors, wattage, features, and date of purchase. One newspaper conducted an internet search for LED street lights in June 2009 and reported published costs ranging from $235-1300 (Incalcaterra 2009). The prices quoted in Table 1 below do not take into account any discounts available through bulk purchases or negotiated agreements. Prices have decreased substantially since the initial release of LED street light technology, while efficacy has steadily improved. A 2008 study prepared for the US Department of Energy reported that "overall the performance of LED luminaires is advancing in light output per chip at a rate of approximately 35% annually, with costs decreasing at a rate of 20% annually" (Navigant 2008).

Location	**Price per luminaire**	**Vendor**	**Wattage**	**Year**
San Jose, CA	$1000 including smart communication system	Echelon/Rudd Lighting	82W	2009
Raleigh, NC	$485	Beta Lighting	167W	2008
Ann Arbor, MI	$460	ReLume Technologies	56W	2008
See Endnotes for San Jose, PE, and Ann Arbor respectively for references.				

Table 1 – LED Luminaire Price Comparison

For more on financing LED retrofit projects, see the Best Practices section of this Guide.

Maintenance Savings

One of the most compelling benefits of LED street lights is their longer operational life and the reduced maintenance costs. LEDs are estimated to last a decade, although warranties for LED luminaires typically last three to ten years. Most projects assume LED lifetimes of 50,000-100,000 hours compared to 8,000-24,000 hours for HPS and metal halide street lamps.

Ann Arbor's pilot street light program reported that "maintenance savings alone are sufficient to make LED fixtures cheaper on a lifecycle basis than conventional fixtures" (Ann Arbor, no date). Banff, Canada estimates a 93% reduction in maintenance costs (Banff 2007b).

The maintenance costs of LEDs can be reduced further if the luminaires are connected to remote monitoring systems (RMSs) (CCI 2009). The City of Los Angeles, which maintains the second largest municipal street lighting system in the US, is connecting its network of LED street lights to an RMS that tracks real-time performance data. "Equipment failures are tracked, logged and synchronized with …maintenance work orders" (CCI 2009).

Similarly, LEDs can reduce the maintenance costs of traffic signals and exit signs, since the incandescent lamps they are replacing typically last up to about 8,000 and 5,000 hours, respectively.

At least one company, OSRAM SYLVANIA, offers an LED retrofit kit that can be installed directly into existing HID street and parking lot light fixtures. According to the manufacturer, this product lasts two to six times longer than HID lamps (50,000 hours), eliminates services calls for cycling HID lamps, reduces energy consumption up to 80% (a 40-watt array replaces a 250-watt HID lamp), improves light quality, and is free of mercury, lead and UV light (Sylvania).

Energy Savings

LED street lights offer a 35-75 percent energy savings compared to HPS street lights. According to a representative of the Manassas, VA Electric Utility, an LED street light can save up to 8,400 kilo-watt hours of energy savings over its lifetime. The rep also noted that "each new light would cut out as much greenhouse gas (CO_2) as the average passenger car produces in 14 months of driving" (VA 2008). The City of Los Angeles reported that from a power perspective, the LED street lights it evaluated in its pilot test "exceeded its expectations" and note that it expected the efficiency to climb as the technology improves over the next couple of years." (LA BSL 2009c)

Table 2 below lists wattage reductions achieved in several LED street light pilot test programs as well as the expected energy savings (%) as calculated by pilot program managers.

LED street lights are increasingly being combined with technologies that can dim their lights during dusk and dawn or shut down the lights using a timer or motion detector. These remote power management systems can significantly reduce energy consumption. LED street lights have very low power requirements, so they can be easily powered by a localized renewable energy system such as a small solar panel or wind turbine. This makes them useful in remote locations and allows them to be installed without cutting pavement, which dramatically reduces installation costs.

Location	LED wattage	Existing wattage	Expected savings
Ann Arbor, MI	56W	100W (metal halide, including ballast energy use)	50%
Banff, Canada	70W	100W (metal halide, nominal, not including ballast)	36%
Los Angeles, CA	46-88W	100W (HPS, nominal) [138W including ballast energy use]	35-65% [Actual]
Raleigh, NC	167W	200-250W (HPS, nominal, not including ballast energy use)	40-50%
San Francisco, CA	41.25-69.21 W	100W (HPS, nominal) [138.32W including ballast energy use]	50-70% [Actual]
West Sacramento (Raley's)	105W average (Bi-Level LED: 149W high power @ 55% time + 52W low power @ 45% time)	320W (metal halide, nominal) [346W including ballast energy use]	70%
See Endnotes for Ann Arbor, LLFY and Banff 2007b, Los Angeles, PE, ES respectively			

Table 2 - Wattage Reductions in North American LED Street Lamp Pilots

Because LEDs are very long-lasting, local governments can reduce the energy needed to manufacture and transport these products. They even reduce the amount of vehicle fuel that is burned- often diesel- when street lights are serviced because they require very little maintenance.

LEDs are less fragile than most conventional lamps and therefore are less susceptible to breakage due to vandalism or vibration (from, e.g., earthquakes, wind, or rain). LEDs are also safer to handle during installation because they are less likely to shatter and are not as hot as incandescent and HID bulbs. In addition, LEDs do not emit UV radiation when lit (unlike many HID street lamps).

Disposal Savings

HPS, metal halide, mercury vapor, and induction lamps, which are commonly used for commercial exterior lighting applications, contain mercury. Consequently, they typically must either be recycled to recover the mercury and other components or disposed of as hazardous waste. Either option adds to their total operational costs, whereas LEDs do not contain any hazardous substances and may be disposed of at no additional cost. Most of the pilot tests we reviewed did not include recycling/disposal costs associated with mercury-containing street lamps in their cost analysis, and there is little data available documenting lamp recycling costs to large-volume purchasers such as municipalities.

Traffic Signal Costs

The average payback period for retrofitting incandescent traffic signals with new LED lamps that meet EPAct

2005 standards is 3 years, but can range from 0.5 to 5.8 years. Eight municipal case studies report annual savings ranging from $3,854 to $6 million due to decreased energy use and maintenance costs.

LED traffic signals are readily available in all parts of the U.S. and cost less than $300 per fixture and less than $125 per bulb; with red diodes costing the least. These LED bulbs last up to 10 years and consume 5-22 watts, whereas incandescent bulbs last about two years and consume up to 150 watts. The cost of LEDs has decreased dramatically over the past several years, leading to lower upfront costs, and, consequently, shorter payback times. The calculations below were made with the EPA's Traffic Signal Cost Calculator, using wattage recommendations given in the RPN Model Specification found in this guide.

	Incandescent Wattage (Annual Energy Consumption in kWh)	**LED Wattage** (Annual Energy Consumption in kWh)	**Annual Cost Savings per LED** (at $0.10/kWh)
12-in. Red Ball (55% duty cycle)	150 (723)	10 (48)	$67.50
12-in. Red Arrow (90% duty cycle)	150 (1183)	7 (55)	$112.80
12-in. Green Ball (45% duty cycle)	150 (591)	11 (43)	$54.80
12-in. Green Arrow (10% duty cycle)	150 (131)	7 (6)	$12.50
Stop Hand Display	67 (528)	8 (63)	$46.50
Walking Figure Display	67 (59)	8 (7)	$5.20

Table 3- Energy and Cost Savings of Incandescent vs. LED Traffic Signals

<u>Traffic Signal Modules</u>

The greatest barrier to adoption of LED traffic signals is their initial cost, with LED bulbs costing as much as 50 times more than a $3 incandescent bulb. These upfront costs, however, are routinely recouped with energy savings and reduced maintenance costs.

Retrofitting a single traffic signal module to use LED fixtures and bulbs costs $300 or less, and it leads to annual energy savings of 1,266 kWh and about $125. As energy costs increase, the annual savings is even greater.

Incandescent signals require replacement every one or two years, and the labor required for maintenance comprises a significant portion of the operating costs of traffic signals. Replacement typically requires a bucket lift truck and maintenance personnel to switch bulbs. The longer lifetime of an LED saves approximately $50 in maintenance costs alone over its 10 year lifespan compared to a typical incandescent.

Using January 2009 electricity prices and conservative pricing information for LED bulbs, payback time for an LED traffic signal module retrofit is 2 years and the total return on investment is about 200%. As electricity prices increase and the cost of LED bulbs decreases, the payback time becomes shorter and the return on investment increases.

Arrow Signals
Conversion to LED saves about 1,253 kWh of energy and about $125 per year in energy costs. Using LED arrow signals saves about $50 per bulb in maintenance costs over its 10 year lifespan.

Pedestrian Signals
LEDs save 477 kWh of energy and about $50 per year. This lower energy consumption, along with maintenance savings of about $50 over the 10 year lifespan work together to offset the average LED pedestrian signal system cost of $300.

Financing and Incentives
Local incentives may be available to help finance your LED retrofit. For example, Puget Sound Energy offers an incentive of up to $20 for each LED traffic signal bulb (PSE 2009). Pennsylvania's Sustainable Energy Fund has a financing program to help municipalities retrofit their traffic signals (SEF 2009). The State of California offers low-interest loans for energy efficiency projects by local governments, schools and hospitals. $26 million is available and the maximum loan amount is $3 million (CA 2008). Xcel Energy provides up to $65 in incentives toward LED traffic signals in Minnesota. It also has incentives for exit signs (Xcel, 2008).

The Federal Energy Efficiency and Conservation Block Grant Program made $2.7 billion available to city and state government agencies to improve energy efficiency and reduce energy use and fossil fuel emissions in their communities (DOE 2009b).

Quality

Exit Sign Quality

LED Exit Signs

According to the US Environmental Protection Agency, "LED exit signs are usually brighter than comparable incandescent or fluorescent signs, and have greater contrast with their background due to the monochromatic nature of the light that LEDs emit." (EPA, undated)

Common features of all LED exit signs include compliance with UL, NFPA and OSHA Illumination standards. An increasing number of LED exit signs have battery back-ups.

LED exit signs differ in their wattage. While federal law requires all exit signs sold in the US to consume no more than 5 watts per face (EPACT, 2005), some LED exit signs use less than 1 watt per sign.

LED exit signs differ in the color of their letters and face plates. While New York City, Chicago and Los Angeles require all exit signs to have a white background and red letters, other jurisdictions require green letters or allow either color to be used.

Some, more expensive LED exit signs offer multiple mounting options, a wet-rating (for outdoor and restroom applications), an expanded temperature range, and ancillary equipment such as emergency lighting and remote testing capabilities.

LEC Electroluminescent Exit Signs

A new generation of electroluminescent exit signs use light-emitting capacitors (LECs), which consume about a quarter watt of electricity and can last up to 30 years. Suppliers of LEC exit signs claim its benefits include:

- Extremely low power requirements
- Twice the life of LED exit signs without significant fading
- Brighter illumination than LED exit signs during emergency battery usage (The Exit Store)

LEC signs are available primarily as stencil-type signs and only offered with green letters and, consequently, may not meet all state and local building codes.

Photoluminescent Exit Signs

These signs do not need to be plugged in, but have limited applications. According to the US Department of Energy, "Non-electrically powered photoluminescent (PL) exit signs utilize a glow-in-the-dark material to provide illumination. While PL exit signs do not require a direct connection to a source of electrical power to operate, they must be charged by another light source in order to function properly. Therefore, PL exit signs are not suitable for all applications. In locations with proper charging sources, PL exit signs can have an unlimited service life." (DOE, 2005)

Similarly, the US Department of Defense cites a number of restrictions with these products: they must be charged by other lights at all times, they must be installed indoors, and they cannot be exposed to direct sunlight or wide temperature ranges (DOD 2006).

Cold Cathode Exit Signs

Some EPAct-compliant exit signs contain cold-cathode fluorescent lighting (CCFL) technology. CCFLs are 1/8" thick "lamps" that are commonly used to "back-light" TV sets and computer monitors. At least one company has integrated this white lighting source into its exit signs. Because they have a lower energy draw, a longer rated life, and lower mercury content than conventional "preheat" and compact fluorescent lamps (CFLs) that have been used to illuminate edge-lit and other types of exit signs, they can be considered environmentally preferable for those applications that tend to rely on "white light." In addition, according to a manufacturer of this product, because CCFLs are "significantly brighter than new LED sign technology, they make it easier to see in emergencies." (T-1 Lighting)

Nevertheless, CCFL-lit exit signs use more energy, about 4-8.5 watts (not including the battery charger), than most LED signs, and contain mercury. As such, they must be handled as universal waste at the end of their useful life and either recycled or sent to a hazardous waste disposal facility. Consequently, they do not comply with the RPN Model Specification for Exit Signs.

Tritium Exit Signs
"Tritium" self-luminescent exit signs remain lit without electricity, but contain a radioactive material that requires special handling and disposal. According to the US Environmental Protection Agency (EPA), "If the tubes in the [Tritium] exit signs are severely damaged, the tritium, which exists in the sign as a high temperature gas, might escape into the local area but most likely will quickly disperse in the air. Because a damaged exit sign will have relatively high levels of tritium in it, you should not handle it." (EPA, undated) Due to their hazardous components tritium exit signs are not recommended in this guide and facilities should remove them as soon as possible during building renovation or lighting retrofit projects, or routine maintenance. For more information about tritium-containing exit signs, visit http://www.epa.gov/radtown/exit-signs.html.

Battery-powered Exit Signs
A small percentage of exit signs are powered only with batteries. Battery-powered signs are the least reliable type of exit sign since they do not have a back-up power supply, although they may be used in facilities that lack electricity. Facility operators must ensure that the batteries remain fully charged and/or routinely replace them, or they risk the safety of building occupants. These exit signs are not recommended in this guide.

Exit Sign Retrofit Kits
There are two types of exit sign retrofit kits that meet the new energy efficiency requirements and are considered environmentally preferable: LEDs and cold cathode fluorescent lamps (CCFLs). See Addendum V**:** When to Retrofit vs. Replace an Old Exit Sign for more information.

LED Retrofit Kits
LED retrofit kits replace the inside electrical hardware of incandescent- or fluorescent-lit exit signs. Choose between a variety of colors and styles for three types of LED retrofit kits:

1) LED lamp arrays with a screw-in base that use an existing socket
2) LED lamp arrays that come with a separate mounting bracket and are hardwired into the building's electrical system; and
3) LED lamp arrays that come with a pin-base and can be used to illuminate edge-lit exit signs.

Ancillary components such as base adaptors, red or green diffusers, and replacement batteries may also be needed to effectively utilize LED retrofit kits. See guidance below about when to retrofit versus replace an existing exit sign.

Cold Cathode Exit Sign Retrofit Kits
These kits can be used to retrofit fluorescent edge-lit exit signs. At least one company has integrated this white lighting source into an exit sign retrofit kit that uses 4-5 watts of electricity and has a rated life of 10 years (other CCFL exit sign retrofit kits use 8-9 watts). Most LED exit signs, in contrast, emit either red or green light. According to a manufacturer, T-1 Lighting CCFLs maintain their brightness better than LEDs, (T-1 Lighting). Nevertheless, CCFL exit sign retrofit kits are not recommended in this guide since they use more energy than the RPN Model Exit Sign Specification allows and contain mercury.

Street Light Quality

A number of pilot projects report high quality performance of LED street lights, including: controllability, directionality, durability, visibility, and reliability. The City of Ann Arbor, Michigan reported the benefits of LEDs as reduced energy consumption, longer lifetime, directionality and controllability (Ann Arbor, no date). Raleigh, North Carolina reported improved visibility when it replaced HPS street lamps with LED lights (PE 2009). The City of Los Angeles reported that its new LED streetlight units "are more durable and damage resistant than other technologies, greatly reducing the City's maintenance costs and providing more reliable lighting for City residents" (LA 2009).

Ann Arbor attributes a significant improvement in quality to the light output and color rendition of their LEDs. Public response to the Ann Arbor pilot was "overwhelmingly positive (81 of 83 comments)" (Ann Arbor). Cities like Ann Arbor are finding better performing products on the market every year. Similarly, in response to the City of Los Angeles' Public Perception Survey, 59% of the residents indicated that they "strongly preferred" the new LED street lights, while only 21% said they "strongly preferred" the old, conventional HPS street lights. (LA BSL 2009c)

Summary of positive LED street light qualities:

- LEDs direct light where it is desired – toward streets and sidewalks – and away from homes, yards, and the sky, reducing light pollution (Ann Arbor, no date).
- Each LED bulb is made up of many small lights, making LEDs less vulnerable to damage or vandalism (VA 2008).
- LEDs, which operate with electronic systems, can be controlled to brighten or dim, and they can be turned on and off instantly, allowing them to be used with motion sensors. Metal halide and HPS street lights cannot be dimmed and have a re-strike time of several minutes, making them incompatible with motion sensors (Ann Arbor, no date).
- Facilities that are lit with LEDs are often considered safer (Raleigh 2007).
- According to a pilot test conducted in the city of Banff in Alberta, Canada, LED street lights do not attract insects (Banff 2007a).
- LED street lights do not cycle at the end of their life. Moreover, unlike conventional street lights, LEDs can easily be equipped with sensors that send an electronic signal to a central location indicating that a light needs replacing. Often, LED street lights do not go out completely; instead individual diodes may fail, leaving many others in place so that the area is not completely unlit.
- LEDs emit a brighter, whiter light that has improved visibility over yellow sodium street lighting. According to Pacific Gas and Electric, one of the key advantages of LEDs is "improved night visibility due to higher color rendering, higher color temperature and increased illuminance uniformity" (PG&E, no date).

Quality Concerns

The quality issue with LED street lights is of utmost importance. No other light source has such widespread variation in performance, output, efficiency, and longevity. And to make matters worse, this variation is directly tied to cost. However, there are now industry standards and the soon to be released ENERGY STAR Standard for Solid State Luminaires that can help a purchaser avoid the potential pitfalls.

The quantity and quality of light output from LEDs can vary dramatically from product to product but an increasing number of pilot tests have reported positive results over the past two years. Poor performance (including dark spots or unacceptably high amounts of glare or harmonic distortion) can be avoided by pilot testing products before going out to bid for large quantities- or specifying ENERGY STAR rated street lights when they become available.

Lumen Depreciation: All LEDs fade over time. When that happens, the LEDs do not go completely dark, but their light levels eventually will fall below original specifications and standards. In 2006, the U.S. Department of Energy reported that high-power white LEDs typically have an estimated useful life of 35,000 to 50,000 hours (based on manufacturer data). This assumes that 70% of the original lumens are maintained during that period. End users can address potential fading problems by specifying that the product must have a minimum lumen maintenance of approximately 70% over the life of the product, or be covered by warranty and replaced by the supplier (DOE 2006).

The three major U.S. lamp manufacturers (GE, Sylvania, and Philips) have developed lines of "non-cycling" HPS lamps that last longer, and contain approximately 90% less mercury than conventional HPS lamps. Induction fluorescents, whose typical lifetime is 100,000 hours, have a relatively low mercury-content per lumen-hour compared to HPS and metal halide street lamps.

Overheating

LEDs can fail prematurely due to overheating. This problem occurs more frequently with higher-wattage LED arrays typically used for highway lighting. Some manufacturers have addressed this through design changes or add-on devices such as fans or other heat-dissipating equipment.

Although LEDs improve visibility, they do not always meet current US Department of Transportation (DOT) regulations, which measure light output strictly in "footcandles." LEDs, which have a much higher Color Rendering Index (CRI) than traditional street lights, and emit more "pupil lumens" – which means their light is more usable to the human eye, which improves visibility. An LED street lighting pilot test conducted in Raleigh, NC, for example, reported that the visibility of its downtown street where LEDs were pilot tested increased due to improved color (associated with blue-white light) and uniformity despite a 43% reduction in footcandles on the roadway." Unless federal transportation standards are revised to account for this effect, municipalities and utilities may need to install additional street lighting poles and fixtures to meet current standards. The Illuminating Engineering Society and others are working to address this issue" (PE 2009). LEDs can reduce, but do not necessarily eliminate, light pollution, and therefore may interfere with the work of astronomers at nearby observatories (Smith 2009).

Traffic Signal Quality

LEDs are now the industry standard for new traffic signals. LEDs generally have lifetimes much longer than incandescent bulbs, lasting about 10 years, and are composed of a matrix of small lights which will gradually fade in intensity instead of burning out all at once. Since LEDs do not burn out as often, there are fewer instances of extinguished traffic signals, meaning fewer accidents and less driver confusion. Maintenance crews benefit from the long lifetime of LED bulbs; they spend less time out on streets and can focus on other maintenance projects.

There is little or no difference between LEDs and incandescent bulbs in terms of light intensity, and they can both serve as effective traffic signals (UCB 2002). Some users say LEDs provide a brighter light, which is useful when sun glare make it difficult to see traffic signal colors. The directional light provided by LED bulbs is ideal for traffic signal operation because it appears extremely bright to someone standing directly in front of the signal.

One challenge is determining the life of an LED in real-world conditions. Moisture and high temperatures may have an adverse effect on the useful life of LEDs. The U.S. Department of Energy uses the Lighting Research Center's definition of an LED's useful life as the point at which light output has declined to 70% of initial lumens (L_{70}) (DOE, 2006). The 5-10 year lifetimes claimed by LED bulbs may not reflect this definition, and therefore should be examined further to determine actual life expectancy. Nonetheless, red and green LED traffic signals can be expected to have useful L_{70} periods of 60,000-100,000 hours based on manufacturer's test data (Color Kinetics). This far exceeds the 8,000 hour rated life of a typical incandescent bulb. Furthermore, LEDs do not flicker, can be dimmed, do not contain toxic substances, and can be recycled.

Several other traffic signal technologies have been tried other than LEDs and incandescent, including the following, each of which has certain drawbacks:

Cold Cathode
Early experiments using cold cathode technology as a traffic signal light source were first tried around World War II. These were met with considerable power supply problems that led to failure. However, power supply improvements and a shift from non-solid state to solid state electronics have led some communities to reconsider cold cathode for traffic signals. Portland, Oregon, for example, tested cold cathode technology as an alternative light source for the city's traffic signals. One manufacturer suggests that cold cathode traffic signals, with an estimated life of 10 to 17 years, could reduce power draws by 75 percent. Red signal retrofits in regions with relatively low electric rates (e.g., less than $0.05 per kWh) would pay for themselves in about 7 years.

Electroluminescent Panels
Electroluminescent panels appear too dim for use in signals. Additionally, they have a relatively short life and a history of production problems that limit their market readiness.

Radio Frequency Induced Fluorescent Sources
Radio frequency induced fluorescent sources have been tried by at least one manufacturer. However, their energy performance is currently no better than fluorescent sources, which cannot compete with the energy savings offered by LED and potentially by cold cathode signals.

Fiber Optics
Fiber optic pedestrian signals and red arrows have been tested and were found to be inadequate by California's Department of Transportation (ACEEE 1998).

Supply

Exit Sign Supply

All exit signs manufactured for sale in the United States on or after January 1, 2006 must meet EPAct 2005 criteria, which requires them to use no more than 5 watts per face (or 10 watts for double-sided signs). RPN recommends using the model specification detailed in this guide, which has energy efficiency standards that exceed the national standards (maximum 5 watts per sign) and other safety and technical features such as a battery back-up (except for self-illuminating models), illuminated arrows, ability to work at both 120 and 277 volts, a minimum 5-year warranty, and supplier take-back. A wide range of LED- and LEC-illuminated exit signs, self-illuminating exit signs, and LED-illuminated exit sign retrofit kits are available on the market that can meet RPN specifications. Some LED and LEC exit signs are available with additional features such as ancillary lighting, larger letters, Braille, damp/wet location and extreme temperature approval, and self-diagnostic and remote monitoring capabilities.

Street Light Supply

Street lights illuminated by LEDs are available for a wide range of applications including, but not limited to:

- Streets and some highways (depending on the speed limit)
- Parking lots and garages
- Parks, beaches and pedestrian walkways
- Bus shelters and rest stops
- Security and other exterior lighting applications
- Street signs

While some LED street lights are relatively simple, others have sophisticated features. For example, according to an article in USA Today: "Besides cutting the $4 million annual electric bill for streetlights, San Jose's LEDs will have transmitters and receivers so they can alert the city when maintenance is needed. They can be dimmed overnight, brightened when pedestrians are near and flash to guide first responders." Other products, equipped with solar panels or wind turbines that can power the lights, prevent the need to cut into roads, and even feed excess energy back into the power grid (Keen 2009).

Traffic Signal Supply

All traffic signals manufactured on or after January 1, 2006 must meet EPAct 2005 criteria, so availability of these signals is not an obstacle. RPN recommends using the model specification detailed in this guide, which has energy-efficiency standards that exceed the national standards. Each of the energy-efficient products detailed in RPN's model specification is offered by several manufacturers, ensuring sufficient competition for low-bid contract procurement requirements.

See the Products section for information about suppliers of LED exit signs, street lights and traffic signals.

Responsible Purchasing Network, Model Policy for LED Exit Signs, Traffic Signals, and Street Lights, 2009

RPN's Model LED Policy is designed to align lighting purchasing practices with energy efficiency, green building, toxics reduction, and zero waste goals by using LEDs to lower electricity use, eliminate toxic substances, reduce lighting maintenance, and improve visibility. *(It may be appropriate to make explicit exceptions in the policy for specialty lighting needs)*

[Jurisdiction/Organization] shall:

1. Establish efficiency standards for all new lighting equipment it will purchase or lease including luminaires, fixtures, ballasts and lamps.
    a. All lamps, ballasts, fixtures and luminaires purchased or leased by [Jurisdiction/Organization] shall achieve no less energy efficiency than the minimum required by the director through rulemaking. At a minimum, all LED equipment shall meet or exceed RPN's model specifications.
    b. No lamps purchased for use in an exit sign, traffic signal, or street light shall be incandescent.
    c. Energy conserved by purchasing decisions involving LEDs shall be calculated every year, and used to justify implementation of more LED projects.
2. Establish energy conservation goals and develop and implement management strategies to meet those goals.
3. Expand lighting recycling by requiring:
    a. vendors that bid on contracts for lighting equipment to offer lamp recycling services, preferably at no additional cost to [Jurisdiction/Organization].
    b. vendors to certify that the lamps they collect from [Jurisdiction/Organization] are recycled following the Basel Action Network's Electronics Industry Pledge of True Stewardship, which can be found at [http://www.responsiblepurchasing.org/purchasing_guides/led/policies/electronics_recycler_pledge.pdf].
    c. that all mercury-added lamps generated by [Jurisdiction/Organization] will be recycled (even if not legally required to do so because it qualifies for a small quantity generator exemption.)
    d. vendors to offer employee education on the proper management of and recycling options for all mercury-containing lighting equipment.

Sample Policies	Exit Signs	Traffic Signals	Street Lights
RPN Model Policy Overarching lighting and energy efficiency policy designed to use LEDs to lower electricity usage, eliminate toxic substances, and reduce lighting maintenance.	✓	✓	✓
Federal Policies			
Energy Policy Act (EPAct), 2005 Federal energy-efficiency standards require that all illuminated exit signs and traffic signals manufactured and offered for sale in the US on or after January 1, 2006 must meet relevant ENERGY STAR specifications.	✓	✓	
Department of Defense (DOD), Fire Protection Engineering for Facilities, 2006 US Department of Defense adopted guidelines for all US military facilities that requires internally illuminated signs to be light emitting diode (LED) type, electroluminescence (LEC), or cold cathode type, and prohibits incandescent and tritium exit signs.	✓		
International Dark-Sky Association (IDA) and Illuminating Engineering Society of North America (IESNA) Joint Task Force, Model Lighting Ordinance, 2009 This ordinance is under development at www.darksky.org. It addresses light pollution from street lighting and other exterior lighting.			✓
State Policies			
Colorado, Executive Order: Greening of State Government: Goals and Objectives (D0011 07), 2007 The State of Colorado issued two Greening of State Government executive orders that direct State agencies and departments "to reduce overall energy use in all state facilities by 20% or more no later than the end of fiscal year 2011-2012 and determine the feasibility of energy performance contracting."	✓	✓	✓
Colorado, Executive Order: Greening of State Government: Detailed Implementation (D0012 07), 2007 This E.O. directs the Greening the Government Manager and Council (established by D0011 07) to implement energy efficiency management. This includes, but is not limited to, requiring agencies and departments to purchase ENERGY STAR-rated equipment, as available, and to utilize the energy savings features of that equipment.	✓	✓	✓
Utah, Executive Order on Improving Energy Efficiency, 2006. Sets a goal of increasing energy efficiency in State facilities by 20% by 2012. Directs state employees to adopt energy efficiency and conservation measures.	✓	✓	✓
Arizona, House Bill 2390, 2005 Arizona requires all traffic signals and exit signs to meet ENERGY STAR requirements.	✓	✓	
Minnesota, Outdoor Lighting Model Ordinance, 2008 This policy allows the use of State funding for outdoor lighting fixtures only if "full consideration has been given to energy conservation and savings, reducing glare, minimizing light pollution, and preserving the natural night environment."			✓
Local Policies			
St. Petersburg, Florida, Executive Order Establishing Policies Consistent with the City of St. Petersburg Green City Initiatives, 2008 This E.O. directs the city to "convert existing street light system, where appropriate, to more energy-efficient poles and fixtures" and "convert the City's traffic signal system to LED lights."		✓	✓

New York, NY, Energy-Efficient Product Purchasing Law (Local Law 119), 2005 "No lamp purchased or leased by any agency shall be an incandescent lamp if a more energy-efficient lamp is available that provides sufficient lumens and is of an appropriate size for the intended application."	✓	✓	✓
Pitkin County, CO, Board of County Commissioners Resolution Endorsing Climate Protection (038-2006), 2006 This policy sets energy-efficient goals in order to alleviate global warming. Its goals include building code improvements using USGBC's LEED program as a guideline, retrofitting county facilities with energy-efficient lighting, and purchasing energy-efficient equipment and appliances for County use.	✓	✓	✓
Palo Alto Climate Action Plan Chapter on Sustainable Purchasing, 2007 This policy directs city departments to prioritize services that have an immediate reduction in greenhouse gas emissions and similar or lower costs, and to consider total product cost in evaluating City purchases.	✓	✓	✓
San Francisco, CA, Resource Efficiency Requirements (Section 705), 2004 This ordinance directs city departments to require that "at the time of installation or replacement of broken or non-functional exit signs, all exit signs shall be replaced with light-emitting diode (L.E.D.)-type signs" and directs that edge-lit compact fluorescent signs may be used as replacements for existing edge-lit incandescent exit signs."	✓		
Teton County and Jackson Hole, WY, Energy Efficiency Action Plan, 2007 Outlines plans to conduct energy use audits, increase building efficiency using USGBC's LEED program as a guideline, and conserve energy through improved operations.	✓	✓	✓
Minneapolis, MN, Street Lighting Policy, 2009 This policy promotes the use of street lighting equipment that improves safety and sustainability chosen based on life-cycle costing. Consistent with this policy, Minneapolis started a pilot test of LED street lights to replace its HPS street lights in 2009 (Minneapolis 2009).			✓
San Jose, CA, Streetlight Conversion Policy, 2008 This policy allows the City of San Jose to substantially reduce its operating and maintenance costs for public streetlights and pedestrian lights, help address the City's energy and hazardous waste reduction goals, and provide the means by which the City can strive to meet its goal, as identified in *San Jose's Green Vision,* to "replace 100 percent of its streetlights with smart, zero emission lighting" by 2022.			✓
University Policies			
University of California System, Policy on Sustainable Practices, 2007 This policy recommends that University operations "incorporate the principles of energy efficiency and sustainability in all capital projects, renovation projects, operations and maintenance within budgetary constraints and programmatic requirements." Consistent with this policy, at least one campus in Santa Barbara, CA (UCSB), has installed 23 LED "test" street lights. The university reported a 44% energy savings in this pilot test and is now converting to LED street lights campus-wide (LED – UCSB, no date). UCSB is part of a nationwide LED University Initiative; for more information, see www.leduniversity.org.			✓
UC Berkeley, Radiation Safety Committee, Tritium Self-Illuminating Exit Signs, 2001 This policy effectively bans the use of tritium exit signs and ensures their proper handling and end-of-life management.	✓		

Responsible Purchasing Network Model Specification for LED Traffic Signals

The wattage requirements below exceed EPAct 2005 requirements and are based on available manufacturer data. Each of the product types listed below has several manufacturers that meet the RPN wattage requirements, which should ensure sufficient competition for competitive-bid contracts.

Technical: LED Traffic Signals shall abide by all guidelines of the Institute for Transportation Engineering (ITE) Specification for Traffic Signals.

Lifetime: LED arrays should have a 100,000 hour rated lifetime.

Performance Guarantee: Vendor shall provide a written warranty ensuring that LED luminaires will be replaced at manufacturer's cost if any defects in materials or workmanship are encountered within 60 months of acceptance; or if LED arrays degrade more than 30% within 5 years.

End-of-Life Management: Vendor shall take back used LED arrays at the end-of-life for recycling.

Quality Assurance: Product shall be in compliance with all relevant quality assurance criteria in section 6.3 of the relevant Institute for Transportation Engineers (ITE) Specification for Traffic Signals.

Module Type	California Dept. Of Transportation Specification Wattage (at 25°C)	EPAct 2005 Standards Normal Wattage (at 25°C)	RPN Model Specification Wattage Requirements (at 25°C)
12-in. Red Ball	11	11	10
8-in. Red Ball	8	8	5
12-in. Red Arrow	9	9	7
12-in. Amber Ball	22	N/A	19
8-in. Amber Ball	13	N/A	11
12-in. Amber Arrow	10	N/A	9
12-in. Green Ball	15	15	11
8-in. Green Ball	12	12	9
12-in. Green Arrow	11	11	7

Combination Walking Figure and Hand Display	N/A	13	12
Walking Figure Display	9	9	8
Orange Hand Display	10	13	8

Responsible Purchasing Network Model Specification for LED and LEC Exit Signs

Vendors shall provide LED and LEC illuminated exit signs that meet the following specifications as well as local building and fire codes.

Illuminated exit signs shall:

- Illuminated by light-emitting diodes (LEDs) or light-emitting capacitors (LECs) only;
- Consume (have an input power demand of) no more than 5 watts of energy per sign (including two-faced signs and backup battery charger, excusive of ancillary lighting equipment).
- Meet National Fire Protection Association (NFPA) 101 Life Safety Code;
- Be listed in accordance with UL 924 and bear the UL mark;
- Meet all applicable NEC, NEMA and OSHA standards, codes and other requirements;
- Offer at least a five-year warranty for defects in materials and manufacturing on the sign and lamps and offer at least a three-year warranty for defects in materials and manufacturing on the battery;
- Be capable of working on 120VAC and 277VAC circuits;
- Operate in normal (AC input) and emergency (DC input) battery-powered modes;
- Be equipped with an LED indicator light and test switch;
- Be protected against power surges and outages;
- Have an integrated rechargeable battery backup and charger; battery must provide at least 90 minutes of backup power during an emergency and must not be a lead-acid battery;
- Have universal knock-out "chevrons" pointing to left and right; and
- Have universal mounting apparatus, which allows for wall, ceiling or side mounting.

Vendors shall offer compatible replacement LED lamp arrays.
Preference will be given to products that are RoHS-compliant.

Responsible Purchasing Network Model Specification for LED Exit Sign Retrofit Kits

Vendor shall be able to provide red, green, and white LED exit sign retrofit kits that:

- Contain two LED lamp arrays (each with a candelabra base) as well as two candelabra-to-bayonet base adapters and two candelabra-to-intermediate base adapters; OR
- Contain two LED "lamp arrays" and a hardwire kit and mounting bracket; or
- Contain two LED "lamp arrays," each with a two-pin base;
- Be listed in accordance with UL 924 and bear the UL mark;
- Use no more than 3 watts of electricity;
- Work in exit signs with 6-inch stenciled letters or in edge-lit exit signs;
- Be considered universally compatible (i.e., able to work in a wide variety of signs rather than being designed to work in a specific exit sign model);
- Be protected against power surges and outages; be capable of working on 120VAC (Note: some jurisdictions may want LED retrofit kits that can work on 277VAC circuits and will need to specify them separately); and
- Offer at least a five-year warranty for defects in materials and manufacturing.

Vendors shall offer compatible diffusers and replacement LED lamp arrays and ancillary equipment. Preference will be given to products that are RoHS-compliant.

Sample Specifications	Exit Signs	Traffic Signals	Street Lights
RPN Model	Responsible Purchasing Network Model Specification for LED Exit Signs Sets 5 watt maximum requirement including battery backup; LED and LEC only. LED retrofit kits shall use no more than 3 watts of electricity. Minimum 5-year warranty.	Responsible Purchasing Network Model Specification for LED Traffic Signals Gives wattage requirements that are more stringent than national standards.	City of Los Angeles, Bureau of Street Lighting, Specifications for Solid State Lighting LED Roadway Luminaires, 2009. **See Addendum IV**
Federal		Institute for Transportation Engineers (ITE), "Interim LED Purchase Specification, Vehicle Traffic Control Signal Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules" (VTCSH Part 2). 2005. Nationally accepted standard specification- includes performance requirements and quality testing procedures.	
State	State of Oregon Technical Specifications for Energy Saving/Environmentally Preferable Lamps, Ballasts, Fixtures, Controls and Exit Signs, 2009 Allows LED exit signs and retrofits only Sets wattage limit at 5 watts for single- or double-faced signs and 3 watt limit for individual replacement LED lamp arrays. Requires vendors to offer LED exit signs, retrofit kits, replacement lamps and ancillary supplies. Prohibits sale of incandescent exit sign lamps on State contract.	California Department of Transportation, Purchase Specification LED Signal Modules, 2007 Sets specific wattage requirements for traffic signal modules for different sizes and shapes for red, amber, and green lights. Gives lifetime rated expectancy of 100,000 hours, 48 month useful life and 60 month performance guarantee.	Minnesota Department of Transportation, Specification for Light Emitting Diode (LED) Luminaire Rest Area Entrance and Exit Ramps, 2009 Some entities (such as the Minnesota DOT) have required their LED luminaires to be compliant with the European Union's Restriction on Hazardous Substances (RoHS) Directive, which prohibits the use of lead in most electrical equipment.
Local		City of Boston, Specifications for LED 12" Traffic Signals, 2005 Specification requires LEDs to be able to retrofit to existing signal housing and includes 100,000 hour lifetime expectancy and 60 month performance guarantee.	City of Los Angeles, Requirements for Solid State Lighting LED Roadway Luminaires, 2009 Addresses minimum light output, lumen maintenance, efficacy, CRI, frequency, warranty, color temperature, on- and off-state power consumption, lumen maintenance, weight, size, operating temperature, noise, housing design, and light distribution. Los Angeles requires all LEDs to be compliant with applicable FCC, UL, IESNA and ANSI standards and to be pre-approved in its LED Pilot Project.

There are currently no third party environmental leadership standards for LED exit signs and retrofit kits, traffic signals, or street lamps.

The federally mandated energy efficiency requirement for new exit signs is 5 watts maximum per face. We recommend seeking LED- or LED-lit products that consume 5 watts of electricity or less per sign, including the energy needed to operate the backup battery charger.

For exit signs and traffic signals, the Energy Policy Act of 2005 (EPAct 2005) set the ENERGY STAR standard as the nationwide de facto standard for both products. Hence, both products are lacking a leadership energy standard.

For street lamps, the ENERGY STAR requirements referenced below applies to all Solid State Luminaire (SSL) applications. At the time of publishing, there is a proposed addition for LED Luminaires used for street lighting.

Each of the products in this guide can be used to earn USGBC LEED Credits. The USGBC awards buildings LEED certification at the Certified Silver, Gold, and Platinum levels, based on the number of credits earned in a variety of categories such as Energy and Atmosphere (EA), Indoor Environmental Quality (IEQ), and Materials and Resources (MR). LEED standards reference renewable energy, energy efficiency, mercury reduction, and light pollution. Please see the Standards table below for more information on specific LEED Credits applicable with LED products.

Each of the products in the guide can be used to earn Association for the Advancement of Sustainability in Higher Education (AASHE) Sustainability Tracking, Assessment and Rating System (STARS) Program credits. Version 0.5 of the program criteria included tier two credits in its "Energy and Climate" section that specifically mentions points for the use of LED lighting. Other criteria that may apply are: *OP Credit 8: Reduction in Energy Intensity* and *OP Credit 11: Greenhouse Gas Emissions Reduction.*

Standards	Exit Signs	Traffic Signals	Street Lights
ENERGY STAR	Program Requirement for Exit Signs Version 3.0 (Defunct) Prior to 2005, the primary standard that was used to rate exit signs was ENERGY STAR. In 2005, Congress passed the Energy Policy Act, which set minimum federal efficiency standard for electrically-powered, single-faced exit signs with integral light sources that are equivalent to ENERGY STAR Version 2.0 levels for input power demand, (i.e. 5 watts or less per face). Consequently, ENERGY STAR no longer rates exit signs. For attributes beyond energy consumption, purchasers may also use the below standards for reference.	Program Requirements for Traffic Signals Version 1.1 (Defunct) EPA suspended the ENERGY STAR Traffic Signal specification effective May 1, 2007. In EPAct 2005, Congress passed a new minimum federal efficiency standard for new traffic signals at the same level as the ENERGY STAR specification. All traffic signals manufactured on or after January 1, 2006 must meet these new criteria. This traffic signal specification is based on the ITE's 2005 specification. At this time, only the LED technology meets such requirements and therefore the specification includes terms specific to LED traffic signals.	Program Requirements for Solid State Luminaires Version 1.1 This 2008 standard covers residential LED luminaires and exterior LED luminaires, but the program has proposed additions for LED luminaires used for lighting streets and parking garages. Many of the components of the ENERGY STAR SSL luminaire standards have been integrated into LED street lighting specifications issued by municipalities, such as Los Angeles.
US Green Buildings Council ***Leadership in Energy and Environmental Design (LEED) Green Building Rating System***	Commercial Interiors Energy and Atmosphere (EA) Credit 1.1-Optimize Energy Performance: Lighting Power. 1-3 points. Existing Buildings Materials and Resources (MR) Credit 4-Sustainable Purchasing- Reduced Mercury in Lamps. 1-2 points.	Neighborhood Development Green Construction and Technology (GCT) Credit 15- Infrastructure Energy Efficiency. 1 point.	Neighborhood Development Green Infrastructure and Buildings (GIB) Credit 17: Light Pollution Reduction. 1 Point.
Other Standards	Restriction on Hazardous Substances (RoHS) **Applicable to all LED products.** Fixtures should be compliant with the EU RoHS directive, which requires electrical equipment to be devoid of lead solder and other hazardous materials.	Intertek LED Traffic Signal Certification Program Intertek provides an independent, third-party certification for LED traffic signals for quality assurance purposes only. The certification program incorporates Section 6.3- Quality Assurance Testing of the ITE 2005 Specification for Traffic Signals. The program covers LED traffic signals, arrows, and pedestrian signals. A list of qualified products can be found in the Products section.	International Dark Sky Association (IDA) Fixture Seal of Approval This independent third party certification program certifies luminaires that "minimize glare, reduce light trespass, and don't pollute the night sky."

Products

Use the RPN online product database to find LED products that meet RPN Model Specifications for Exit Signs and Traffic Signals.

Exit Signs

The ENERGY STAR Program has developed a calculator designed to help facilities estimate the life-cycle costs associated savings and climate impacts from using various types of exit signs. To access this calculator go to www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Exit_Signs.xls

Street Lights

Millenia Technologies
LED Streetlight Energy Savings and Payback Calculator
This manufacturer's Excel-based calculator helps municipalities and utilities calculate their energy and maintenance savings as well as greenhouse gas and other environmental benefits of replacing HPS street lights with LEDs.

Alliance for Solid-State Illumination Systems and Technologies (ASSIST)
Parking Lot Luminaire Calculator
This calculator is designed to estimate the efficacy and overall cost of a given parking lot lighting system within a given task area.

Traffic Signals
EPA's ENERGY STAR calculator for Traffic Signal has been updated with recent electricity rates and wattage requirements in the RPN Model Specification to provide a more accurate estimation of your cost and energy savings.
www.responsiblepurchasing.org/purchasing_guides/led/calculator/energystar_calculator_with_RPN Specs.xls

Definitions

Baseline	Basic information gathered before a program begins that is used later to provide a comparison for assessing program impact
CRI	Color rendering index is a measure of light quality; the closer to 100, the more it exhibits true color, similar to sunlight.
Duty Cycle	The amount of time during a specified time period that an LED is energized, expressed as a percentage of the specified time period.
ENERGY STAR	ENERGY STAR, a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, helps residents, public entities, and businesses save money and protect the environment by labeling energy-efficient products.
Environmentally preferable	Products and services that have a lesser or reduced effect on human health and the environment when compared to other products and services that serve the same purpose.
Exit sign	A sign that is permanently fixed in place and used to identify a means of egress.
Fixture	The assembly that holds a lamp (or LED array) and may include an assembly housing, a mounting bracket or pole socket, a lamp (or LED array) holder, a ballast (or LED driver), a reflector or mirror, and a refractor or lens.
Footcandle	The amount of illumination the inside surface of a 1-foot radius sphere would be receiving if there were a uniform point source of one candela in the exact center of the sphere.
Full cutoff luminaire	A luminaire that allows no direct light emissions above a horizontal plane through the luminaire's lowest light-emitting part.
Glare	Direct light emitting from a luminaire that causes reduced vision or momentary blindness.
Hazardous substance	1. Material posing a threat to human health and/or the environment, that can be toxic, corrosive, ignitable, explosive, or chemically reactive 2. A substance that must be reported to the EPA if released into the environment.
HID	A lamp that produces light by passing electricity through gas, which causes the gas to glow. Examples of HID lamps are mercury vapor lamps, metal halide lamps, and high-pressure sodium lamps.
IDA	International Dark Sky Association (www.darksky.org)
Induction fluorescent	An electrodeless fluorescent lamp that typically lasts 60,000 to 100,000 hours and is typically used for high-bay and street lighting applications.
L_{70}	A measure of lumen maintenance that indicates the number of hours an LED array is expected to last during which at least 70% of its initial light output is maintained.
LEC	Light-emitting capacitor
LED	Light-emitting diode

LED Driver	A power source with an integral LED control circuitry designed to meet the specific requirements of a LED lamp or array.
LED Traffic Signal	The generic term used to describe the combination of signal heads or modules that use LEDs as the source of light. The combination also incorporates the housing unit at an intersection, along with any internal components and support structures.
LEED (Leadership in Energy and Environmental Design)	Environmental impacts of a given product or service caused by its production, transportation, use and end-of-life management. A green building rating system developed by the US Green Building Council, which offers credits for the construction, renovation, and operation of several types of buildings.
Life Cycle Environmental Impacts	Environmental impacts of a given product or service caused by its production, transportation, use and end-of-life management.
Light Trespass	Light emitted by a luminaire that shines beyond the boundaries of the property on which the luminaire is located.
Lumen	A standard unit of measurement used to describe how much light is contained in a certain area.
Luminaire	A complete lighting system, including the fixture and lamp and ballast or driver (for LEDs).
Modules	Standard 200-mm (8-in.) or 300-mm (12-in.) round traffic signal indications (balls). They consist of the light source and the lens (usually a sealed unit) that communicate movement messages (stop, caution or prepare to stop, and go) to drivers through red, yellow and green. Arrow modules in the same colors are used to indicate turning movements. Pedestrian modules are used to convey movement information to pedestrians.
NFPA Life Safety Code 101	The National Fire Protection Association (US) developed NFPA 101 Life Safety Code, which addresses the construction, protection and occupancy features necessary to minimize danger to life from fire, including smoke, fumes or panic. Many states and localities adopt this Life Safety Code into their own Building Code standards.
Nominal wattage	The wattage of a lamp excluding the ballast energy use.
Pupil lumens	Determined by the factor $P(S/P)^{0.78}$, where P and S are photopic and scotopic output of the lamp.
Total Cost of Ownership	A financial estimate designed to help consumers and enterprise managers assess direct and indirect costs.
RBRC	Rechargeable Battery Recycling Corporation, which offers free collection and recycling of rechargeable batteries, including those used in exit signs. See www.rbrc.org
RoHS	The Restriction on Certain Hazardous Substances (RoHS) Directive is a law that was adopted by the European Union, which limits the amount of lead, mercury, cadmium, hexavalent chromium and brominated flame retardants that may be allowed in electronics and other electrical equipment sold in the EU marketplace.

UL	Underwriters Laboratories is an independent product safety certification organization that has been testing products and writing standards for safety for more than a century. See http://www.ul.com.
UL 924	Underwriters Laboratories 924 is the most commonly used standard for Emergency Lighting and Power Equipment.

Traffic Signals

State of Wisconsin

For years, the Energy Division staff had discussed LED traffic signals with engineers and purchasing agents from the Department of Transportation (DOT). In 2002, DOT was able to allocate enough money for traffic signal changeout to consider a mass-replacement of LED signals. DOT's decision to purchase LEDs, using ENERGY STAR specifications, was based on the experience of other states and cities as well as technical advice from the Division of Energy. As a further public safety benefit, the low-power LEDs made it possible to install battery backup systems to operate signals during electricity outages. In many smaller communities, the State is also responsible for traffic signals on state highways in the town. The State's use of LED signals thus helped local governments become familiar with the technology, which they were then able to purchase under State contract or from local suppliers.
http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/Wis_2004_purchasing.pdf

Denver, CO

In 1996, the City of Denver's Traffic Operations Division began an ongoing retrofit program to convert its traffic signals from incandescent lamps to LED bulbs. Since then, more than 20,500 traffic signals have been replaced with LEDs. Each installation replaces a 150 watt or 69 watt incandescent bulb with LEDs requiring only 14 watts or 8 watts of electricity respectively. The annual energy savings associated with this reduction are 9.4 million kWh. These savings reduce emissions of 5,300 metric tons of CO_2 each year.[1] In addition, switching to LED signals avoids 23.3 metric tons of SO_2 and 20.8 metric tons of NO_x emissions each year.[2] Although the initial cost of the LEDs is higher than the cost of conventional bulbs, the lower energy requirements of the new LED signals saves over $276,000 each year and the savings on materials and labor are more than $154,000 each year, for total annual savings of over $430,000. The LED signals have a payback period of less than four years and the total cost savings over the lifetime of the fixtures is estimated to be over $6.1 million.
http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/CO_LED.pdf

Assuming a conversion factor of 1.244 lbs CO2 / kWh (The Cadmus Group, Inc. Regional Electricity Emissions Factors Final Report, The Cadmus Group, Inc., 1998, Exhibit 6).
[2]Using emission factors of 5.46 lbs SO2/MWh and 4.89 lbs NOx/MWh (The Emissions & Generation Integrated Database(E-GRID), EPA/Acid Rain Program).

Salt Lake City, UT

Salt Lake City began phasing in the use of LED traffic signals in 2001, with much success. In 2007, the number of traffic signals increased by 50% over 2001 figures, yet the amount of energy used to power these signals decreased during that time by 56%. Converting red and green bulbs with LEDs reduced the amount of energy used by each signal by over 70%. This saves almost 2 million kWh of energy and $115,000 per year with the use of LED traffic signals.

PORTLAND, OR

In 2001, the City of Portland replaced nearly all its red and green incandescent traffic signal lights with LED lamps in the span of three months. The result is annual energy and maintenance savings totaling $400,000 and net payback in less than three years. 13,300 signals were converted to LED (6,900 red signals and 6,400 green signals) at a total cost of $2.2 million. Approximate lamp life of the LEDs is 6 years instead of 2 years allowing for maintenance savings of $45,000 per year. 4.9 million kWh are saved per year with the use of LEDs, saving the City of Portland $335,000 per year. The project managed a net return-on-investment of 44% in total and 37% on energy alone.
http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/portland_news_LED_case_study.pdf

STREET LIGHTS

Ann Arbor, MI

In 2006, the City of Ann Arbor conducted a pilot test of LED globe-style street lights in its downtown pedestrian area. In the pilot test, 57-watt LED luminaires, which have an estimated 10-year lifespan, replaced 120-watt luminaires that contain metal halide lamps, which need to be changed out every two years. As a result of this successful demonstration project, Ann Arbor decided to replace all of its 1,400 pedestrian street lamps with LEDs. The City expects this lighting retrofit project, which was funded by a $630,000 grant from its Downtown Development Authority, to have a 4.4 year payback, save over $140,000/year in energy and maintenance costs, and reduce greenhouse gas emissions by 267 tons.

http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/ann_arbor_LED_Summary.pdf

Los Angeles, CA

Over a five-year period starting in June 2009, Los Angeles will replace 140,000 existing incandescent, metal halide, mercury vapor, and high pressure sodium streetlights with LED luminaires. The city secured a $40 million loan for the project that will be repaid with cost savings over 7 years and expects to receive a $16 million utility rebate. When the project is complete, the city expects to reduce streetlight energy use by 40%, lower carbon emissions by 40,500 tons per year, and save $10 million per year in energy and maintenance costs. Manufacturers are invited to send products to the city for evaluation at no or reduced cost. The city has developed minimum requirements that all LED luminaires must meet, as well as extensive lab and field testing procedures. The city will evaluate new products annually in order to take advantage of continuous evolution of LED technology.

http://www.responsiblepurchasing.org/purchasing_guides/led/case_studiesLos_Angeles_LED_Retrofit.pdf

http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/lacity.pdf

Raleigh, NC

The City of Raleigh, NC worked with its local utility, Progress Energy Carolinas (PEC), to conduct a pilot test of nine decorative street lights surrounding the city's new convention center. PEC replaced fixtures containing 200-watt and 250-watt high-pressure sodium (HPS) lamps and ballasts with 167-watt LED-lit fixtures and leases them to the city. The utility reported that the LED lights are saving 40-50% and estimates that the project will save approximately $100,000 over 20 years. It also noted that the installation was easy, that it has experienced no operational problems to date, and that the LED lights improved visibility even though the quantity of "foot-candles" of light was reduced.

http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/raleigh_LEDStreetLightTestProjectReport.pdf

San Jose, CA

In June 2009, San Jose replaced 115 55-watt (90-watts including ballast), low-pressure sodium street lights with 38-watt LED streetlights in a residential neighborhood in East San Jose. (The LED lights have a capacity of 82 watts but are initially set at 38 watts.) The cost of $1000 per light includes both the luminaire and the communication system. San Jose's RFP required a complete package and did not include a cost breakdown. City staff handled the installation of the LED lights, which was estimated at an additional $100 per conversion. The city anticipates 40% savings in baseline energy use. The communications system and dimming capability provide an additional 10% energy savings. The LED arrays are conservatively expected to last 10 years versus four years for the LPS lamps. San Jose expects that savings in energy and avoided maintenance costs together will total over 65%. The City of San Jose adopted a Streetlight Conversion Policy in November 2008 to "replace 100 percent of its streetlights with smart, zero emission lighting by 2022."

http://www.responsiblepurchasing.org/purchasing_guides/led/case_studies/san_jose_20081216_0604.pdf

Addendum I

EXIT SIGN Baseline Form	1) Do one of these worksheets for every building under your management		
	2) These values can be plugged into the ENERGY STAR exit signs calculator to determine cost and environmental benefit		
Exit Sign Type:	**Quantity**	**Wattage/sign**	**Total Wattage**
Incandescent			
Fluorescent			
Cold cathode fluorescent			
LED			
LEC			
Photoluminescent (no energy)		-	-
Tritium (no energy)		-	-
Battery-powered (no energy)		-	-
Other			
Total Building energy use:			___________Watts

Current Price of Electricity:	_______	dollars/kWh
Annual Electricity Costs:	_______	dollars/year
Annual Maintenance Costs: Include Lamp Replacement, Labor, Disposal costs.	_______	dollars/year
Baseline Exit Sign Costs:	_______	dollars/year

Current energy source:	_______	(Coal, wind, etc.)
Pounds of CO2e/kWh for your energy source[1]:	_______	pounds/kWh
Baseline CO2e emissions	_______	lbs/yr

[1] Refer to energy utility bills and the EPA E-Grid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) OR find your state's emissions coefficients at: (http://tonto.eia.doe.gov/ftproot/environment/e-supdoc-u.pdf)

Exit Sign Retrofit/Replacement Audit Form

________________Surveyor Name __________________Contact #

Exit Sign #	Location	Type of Sign (stencil, edge-lit, etc.)	Type of Lamps in Exit Sign (incandescent, fluorescent, LED, etc.)	Number of Lamps per Sign	Wattage of each lamp	Total Wattage of Lamps in Exit Sign	Wattage of Battery Charger (if unknown, add 2 watts)	Total Wattage of Exit Sign	Replace, Retrofit or Leave as is	Deadline for Conversion
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
TOTAL										

Notes: Incandescent exit signs typically use 30-40 watts of energy for internal illumination.
Common incandescent exit sign lamps include: 15T6 (15 watts) and 20T6.5 (20 watts)
Common linear fluorescent exit sign lamps include: F5T6 and F7T5; 5-, 7-, and 9-watt CFLs are also sometimes used for exit signs.
Fluorescent exit signs also have ballasts that can add to the total sign wattage.

EXIT SIGN Replacement/Retrofit Form

REPLACEMENT/RETROFIT TYPE	Quantity	Wattage/Sign	Total Wattage
LED Exit Sign			
LED Retrofit Kit			
LEC			
Cold cathode fluorescent			
Photoluminescent (no energy)		-	-
Other			

Total Building energy use:	_______Watts

Current Price of Electricity:	________	dollars/kWh
Future Annual Electricity Costs:	________	dollars/year
Future Annual Maintenance Costs: Include Lamp Replacement, Labor, Disposal costs.	________	dollars/year
Future Exit Sign Costs:		dollars/year

Future energy source:	________	(Coal, wind, etc.)
Pounds of CO2e/kWh for your energy source[1]:	________	lbs/kWh
Future CO2e emissions		lbs/year

Savings from Retrofit/Replacement:		
Costs	________	dollars/year
CO2e Emissions	________	lbs/year

[1] Refer to energy utility bills and the EPA E-Grid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) OR find your state's emissions coefficients at: (http://tonto.eia.doe.gov/ftproot/environment/e-supdoc-u.pdf)

ADDENDUM II: STREET LIGHT AUDIT AND RETROFIT/REPLACEMENT WORKSHEETS

STREET LIGHT Baseline Form

Luminaire Type	Quantity	Wattage/Luminaire*	Total Wattage
Incandescent			
Fluorescent			
HPS			
LPS			
Mercury vapor			
Metal halide			
Other			

*include total luminaire wattage including lamps, ballast/driver and monitoring equipment

Total Street Light energy use:		Watts

Current Price of Electricity:	________	dollars/kWh
Annual Electricity Costs:	________	dollars/year
Annual Maintenance Costs: Include Lamp Replacement, Labor, Disposal costs.	________	dollars/year
Baseline Street Light Costs:	________	dollars/year

Current energy source:	________	(Coal, wind, etc.)
Pounds of CO2e/kWh for your energy source[1]:	________	pounds/kWh
Baseline CO2e emissions	________	lbs/yr

[1]Refer to energy utility bills and the EPA E-Grid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) OR find your state's emissions coefficients at: (http://tonto.eia.doe.gov/ftproot/environment/e-supdoc-u.pdf)

STREET LIGHT Retrofit/Replacement Form

Luminaire Type	Quantity	Wattage/Luminaire*	Total Wattage
Incandescent			
Fluorescent			
HPS			
LPS			
Mercury vapor			
Metal halide			
Other			
	Future Street Light energy use:		________Watts

*include total luminaire wattage including lamps, ballast/driver and monitoring equipment

Current Price of Electricity:	_______	dollars/kWh
Annual Electricity Costs:	_______	dollars/year
Annual Maintenance Costs: Include Lamp Replacement, Labor, Disposal costs.	_______	dollars/year
Future Street Light Costs:	_______	dollars/year

Future energy source:	_______	(Coal, wind, etc.)
Pounds of CO2e/kWh for your energy source[1]:	_______	pounds/kWh
Future CO2e emissions:	_______	lbs/yr

Savings from Retrofit/Replacement:		
Costs	_______	dollars/year
CO2e Emissions	_______	lbs/year

[1] Refer to energy utility bills and the EPA E-Grid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) OR find your state's emissions coefficients at: (http://tonto.eia.doe.gov/ftproot/environment/e-supdoc-u.pdf)

ADDENDUM III: TRAFFIC SIGNAL AUDIT AND RETROFIT/REPLACEMENT WORKSHEETS

TRAFFIC SIGNAL Baseline Form

Type of Lamp	Quantity	Wattage/Signal	Total Wattage
Incandescent			
LED			
Other			

Total Traffic Signal energy use:		Watts

Traffic Signal Replacement and Retrofit Audit Form

_________________ **Surveyor Name** ____________ **Contact #**

Traffic Signal #	**Location**	**Type of Sign** (Green Ball 8 inch, Red Arrow 12 inch, Hand, Man, etc...)	**Type of Lamp** (incandescent, LED, etc.)	**Replace or Retrofit? (Deadline)** **Add Deadline date**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Current Price of Electricity:	________	dollars/kWh
Annual Electricity Costs[1]:	________	dollars/year
Annual Maintenance Costs: Include Lamp Replacement, Labor, Disposal costs.	________	dollars/year
Baseline Traffic Signal Costs:	________	dollars/year

Current energy source: **Pounds of CO2e/kWh for your energy source[2]:**	_______ _______	(Coal, wind, etc.) pounds/kWh
Baseline CO2e emissions[3]	_______	lbs/yr

[1]Refer to ENERGY STAR Calculator for Traffic Signals- use value for annual energy cost (Box G-34)

[2]Refer to energy utility bills and the EPA E-Grid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) OR find your state's emissions coefficients at: (http://tonto.eia.doe.gov/ftproot/environment/e-supdoc-u.pdf)

[3]Refer to ENERGY STAR Calculator for Traffic Signals

TRAFFIC SIGNAL Replacement/Retrofit Form

Type of Lamp	Quantity	Wattage/Signal	Total Wattage
Incandescent			
LED			
Other			

Future Traffic Signal energy use:	_______Watts

Current Price of Electricity:	_______	dollars/kWh
Annual Electricity Costs[1]:	_______	dollars/year
Annual Maintenance Costs: Include Lamp Replacement, Labor, Disposal costs.	_______	dollars/year
Future Street Light Costs:	_______	dollars/year

Current energy source:	_______	(Coal, wind, etc.)
Pounds of CO2e/kWh for your energy source[2]:	_______	pounds/kWh
Future CO2e emissions[3]:	_______	lbs/yr

Savings from Retrofit/Replacement:		
Costs	_______	dollars/year
CO2e Emissions	_______	lbs/year

[1]Refer to ENERGY STAR Calculator for Traffic Signals- use value for future annual energy cost (Box B-34)

[2]Refer to energy utility bills and the EPA E-Grid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) OR find your state's emissions coefficients at: (http://tonto.eia.doe.gov/ftproot/environment/e-supdoc-u.pdf)

[3]Refer to ENERGY STAR Calculator for Traffic Signals

Addendum IV: Los Angeles Specifications for LED Street Lighting Luminaires

BUREAU OF STREET LIGHTING
Requirements for Solid State Lighting LED Roadway Luminaires

Issue Date: 03/24/2009

Luminaire Requirements:	
Correlated Color Temperature (CCT)	Nominal CCT (°K) 4000 - 5000
Color Rendering Index (CRI)	Luminaires shall have a minimum CRI of 70.
Off-state Power Consumption	The power draw of the luminaire (including PE or remote control devices) shall not exceed .50 watts when in the off state.
On-state Power Consumption	Shall not consume more than 85 W (not including optional monitoring/control device).
Warranty	A warranty must be provided for the full replacement of the luminaire due to any failure for five (5) years. The warranty shall provide for the repair or replacement of defective electrical parts (including light source and power supplies/drivers) for a minimum of eight (8) years from the date of purchase.
Weight	Luminaire shall not weigh more than 25 pounds.
Operating Environment	Luminaire shall be able to operate normally in temperatures from -20° C to 50° C.
Cooling System	Shall consist of a heat sink with no fans, pumps, or liquids, and shall be resistant to debris buildup.
Dimensions (Approx.)	30" long x 16" wide x 6" tall
Housing	Shall be primarily constructed of metal. Finish shall be gray in color, powder coated and rust resistant. Driver must be mounted internally and be replaceable. Driver must be accessible without tools. All screws shall be stainless steel. Captive screws are needed on any components that require maintenance after installation. No parts shall be constructed of polycarbonate unless it is UV stabilized (lens discoloration shall be considered a failure under warranty).
IESNA Luminaire Classification	Cutoff
Mounting Arm Connection	Luminaires shall mount on 2.375" O.D. horizontal tenon with no more than four bolts and two piece clamp.
PE Cell Receptacle	Luminaires shall have a 3-prong locking ANSI C136.10 photocell receptacle.
House Shield	Shall provide option for house side light control.

LED Module/Array Requirements:	
Lumen Depreciation of LED Light Sources	LED module(s)/array(s) shall deliver at least 70% of initial lumens, when installed for a minimum of 50,000 hours.
Light Distribution	Should be in accordance with IESNA Type III Lighting Distribution. Should also be commercially available in a Type II Distribution.

Power Supply/Driver Requirements:	
Power Factor	Power supply should have a minimum Power Factor of .90
Max amperage at LED	525 mA
Transient Protection	Per IEEE C.62.41-1991, Class A operation. The line transient shall consist of seven strikes of a 100k HZ ring wave, 2.5 kV level, for both common mode and differential mode.
Operating Temperature	Power Supply shall operate between -20° C and 50° C.
Frequency	Output operating frequency must be $\geq$ 120 Hz (to avoid visible flicker) and input operating frequency of 60 Hz.
Interference	Power supplies shall meet FCC 47 CFR Part 15/18
Noise	Power supply shall have a Class A sound rating

Roadway Application Requirements:	
Minimum Light Output	Luminaire shall deliver a minimum of 3200 lumens (initial).
Luminaire Efficacy	$= \frac{\text{Luminaire Light Output(includes fixture efficiency and thermal effects)}}{\text{Luminaire Input Power}}$
Minimum Luminaire Efficacy	40 lm/W

Measurement/Performance/Safety Standards:	
ANSI C78.377.2008	Specifications for the Chromaticity of Solid State Lighting Products.
IESNA LM-79-08	IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
IESNA LM-80-08 (Recommended)	IESNA Approved Method for Measuring Lumen Maintenance of LED Lighting Sources.
UL Standards (Latest Approved)	• **8750** Light-Emitting Diode (LED) Light Sources for Use in Lighting Products • **1598** Luminaires • **1012** Power Units Other Than Class 2 • **1310** Class 2 Power Units • **2108** Low Voltage Lighting Systems

Pre-qualifications for Bidding:

1. The following manufactures have been pre-approved in the City's LED Pilot Project:
2. Participation in the bidding process shall be limited to the above companies.
3. Before the contract can be awarded, the winning bidder shall provide three production samples to the City at no cost for final testing.
4. Upon delivery, quality control testing will be performed by the Bureau of Street Lighting. Testing will be done in accordance with the City's "Special Specifications for the Construction of Street Lighting Systems" (The Blue Book).

Delivery Requirements:

The Company to be awarded the contract must comply with the following deliveries and quantities:
Total units needed the first three months after contract is awarded: 5000

2500 Units- 8 weeks after award of contract
2500 Units-12 weeks after award of contract

5000 Total Units

Penalties:

If the units are not delivered per the above delivery requirements, a penalty of $100 per day per unit will be assessed. If the bidder cannot deliver, the City will have the right to cancel the contract and go to the next qualified bidder.

ADDENDUM V: WHEN TO RETROFIT VS. REPLACE AN OLD EXIT SIGN

The following shall be considered when replacing old exit signs.

There are two alternatives when considering an upgrade or replacement of an existing exit sign. In most cases, the most practical solution is to replace the entire exit sign with a new exit sign fixture. Some applications, however, are better suited for the installation of a retrofit kit rather than a completely new fixture.

There are several factors that can influence a purchaser's or specifier's decision about whether to replace or retrofit an exit sign, including:

- The age of the sign: Relatively old signs (>5 years) are better candidates for replacement since other components including batteries and wires may be reaching the end of their warranty or useful life.
- The quality of the sign: If the sign is a relatively simple and inexpensive sign with few additional components such as emergency lighting, it is a better candidate for replacement than retrofit. Signs with expensive metal housings, additional features, or historical significance are may be better suited for retrofit with LED replacement lamps since the replacement may be higher than budget allows and the retrofit will allow the unique features of the exit sign to be maintained.
- The presence of a back-up battery in your existing exit sign. If your existing exit sign lacks a back-up battery, you may want to replace the entire sign to add this important safety feature. If it does have a back-up battery, consider replacing it at the same time that you retrofit the sign. You may need a different or less-powerful back-up battery than the one that was in the incandescent-lit or fluorescent-lit exit sign since it takes less battery power to operate an LED exit sign. Check with the retrofit kit manufacturer about compatible back-up batteries for their equipment.
- The compatibility of the sign with a retrofit kit. Although LED retrofit kits are available to replace a wide variety of exit signs, including commonly used stencil and edge-lit models, they may not be practical for all applications. When considering a retrofit kit, make sure the exit sign housing can withstand the new lighting source. For example, some older plastic signs may experience thermal damage when retrofitted with a kit. Make sure the retrofit you are choosing is compatible with your existing sign's housing.
- The availability of utility rebates: While most utilities offer rebates to facilities that replace an existing incandescent (or less often, fluorescent) with a new LED, T-1 compact fluorescent, electro-luminescent, or photo-luminescent exit sign, fewer will pay for the installation of retrofit kits. And when they will pay for exit sign retrofits, they will often offer less than for full exit sign replacement. For example: Commonwealth Edison, a Chicago-based utility will pay for the replacement or retrofitting of existing exit signs. Its policy is: "Electroluminescent, photoluminescent, T1 cold cathode and light-emitting diode (LED) exit signs are eligible under this category. All new exit signs or retrofit exit signs must be UL924 listed, have a minimum lifetime of 10 years, and have an input wattage ≤ 5 Watts per face."(ComEd, 2009) Pacific Gas and Electric Company located in the San Francisco Bay area, for example, offers businesses and government agencies $27 per fixture to replace incandescent-lit exit signs with LED models and $15 per fixture for replacing fluorescent-lit exit signs with LED models (PGE, 2009).

- <u>The relative difficulty of installing versus retrofitting your existing exit signs.</u> The installed cost (including labor) of replacing a fixture with a new exit sign is determined by the mounting position and the extent of new wiring that must be accomplished. The cost of installing a retrofit kit is based on the ease of access to existing sign, the difficulty of inserting retrofit kit, and amount of new wiring. While some exit signs may be particularly difficult to retrofit, others may be especially difficult to replace.

- <u>Whether the use of a retrofit kit will ensure that your sign remains under warranty.</u> While all exit signs and retrofit kits are required to have UL-924 (or, in Canada CA UL-924) approval, most also offer limited warranties for defective parts. Installing a retrofit kit in an existing exit sign may void the warranty of the exit sign that is already installed. Or if the original sign is old, its warranty may already have run out. Both the UL listing and warranty of a given retrofit kit may be contingent upon installation in specific, compatible manufacturer's fixtures. The kit may, therefore, void the warranty if it is not installed in proper fixtures. Manufacturers of the exit sign retrofit kit you are considering installing should be consulted about their warranty if there is any concern.

Other considerations when choosing replacements for previously installed exit signs:
In order to meet proper safety code requirements and specify the most appropriate exit sign improvements, it is important to be aware of exit sign formats, power supply, materials and construction, mounting positions, and warranties. The Rensselaer Polytechnic Institute developed important criteria to consider when selecting exit signs (RPI, 1994).

Exit Sign Formats

In order to specify the proper replacement or retrofit measures, it is important to be aware of exit sign formats. There are four typical formats for internally lit exit signs: panel, stencil, matrix and edge-lit.

- *Panel.* Panel format exit signs contain letters and a background that are both illuminated. These fixtures usually contain incandescent or fluorescent lamps (and are therefore prime targets for upgrading).
- *Stencil.* Letters are illuminated and the background is opaque in stencil format signs. Most light sources can be used in this stencil format although many older models still installed in commercial and institutional buildings are lit with incandescent lamps (if half of the stencil sign unlit, it is likely to contain incandescent lamps).
- *Matrix.* In a matrix exit sign, the letters are formed by points of light and the background is opaque. The most common light source is exposed LEDs.
- *Edge-lit.* In more expensive signs, light from an enclosed source is directed through a transparent plate that has letters etched in or attached to its surface. Incandescent, fluorescent, and LED light sources are used for these signs. Therefore, you may need to open it up to determine what type of lamps it contains and whether it is a good candidate for upgrading.
- *Primary and Back-up Power Supplies:* Most exit signs are powered by being wired into the electrical system of the building. It is important to know whether the electrical system uses 120V or 277V power or both. In cases where electricity is not available, facilities can choose exit signs that use batteries as a primary power source or self-illuminated exit signs that glow-in-the-dark without any power input.

It is safest to order signs that are capable of running on either type of power supply.

Back-up Power: Many exit signs contain a back-up rechargeable battery that will keep the sign illuminated – usually for 90 minutes or more – in case the building's electricity is knocked out during a fire or storm. In some instances, however, the back-up (emergency) power to exit signs is supplied by a non-utility generator located on site. Determining the power supply is important when selecting replacement fixtures or retrofit kits.

Mounting Positions: During the site survey of existing conditions, it is important to note how your exit signs are mounted to the various spaces. They can be recessed into a wall, surface-mounted on a wall or ceiling, or suspended on a pendant. It is important to note if surface-mounted signs are flat on the wall or perpendicular to it. It is safest to purchase exit signs with universal mounting hardware that allow for a variety of mounting options.

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