Municipal Guide to LED Street Lighting Conversion

A Step-by-Step Approach to Improving Outdoor Lighting, Saving Energy and Reducing Maintenance Costs

Presented by

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Introduction

Driven by the promise of significant energy and maintenance savings provided by Light Emitting Diode (LED) technology, many cities are struggling with effectively implementing LEDs in their street lighting. There still remains much confusion and misinformation pertaining to this technology. Furthermore, much of the available literature is presented in technical and scientific terms targeted at an academic audience.

This document is intended as a practical, user-friendly, step-by-step guide for individuals responsible for municipal street lighting, even if they lack a formal lighting background. Thus, the use of lighting terminology in this guide has been minimized.

The "Municipal Guide to LED Street Lighting" covers the essentials of the retrofit process and creating a well-informed streetlight specification. It presents elements essential to understanding the basic features and function of street lighting, getting feedback from key stakeholders, and the benefits of involving manufacturers in the consideration process. It will aid in creating the architecture of a plan that considers priorities, product requirements, system life, finances, and how to avoid pitfalls. Ultimately, your plan will have to be tailored to the specific requirements of applications unique to your own project.

We welcome your feedback and questions. Feel free to contact a
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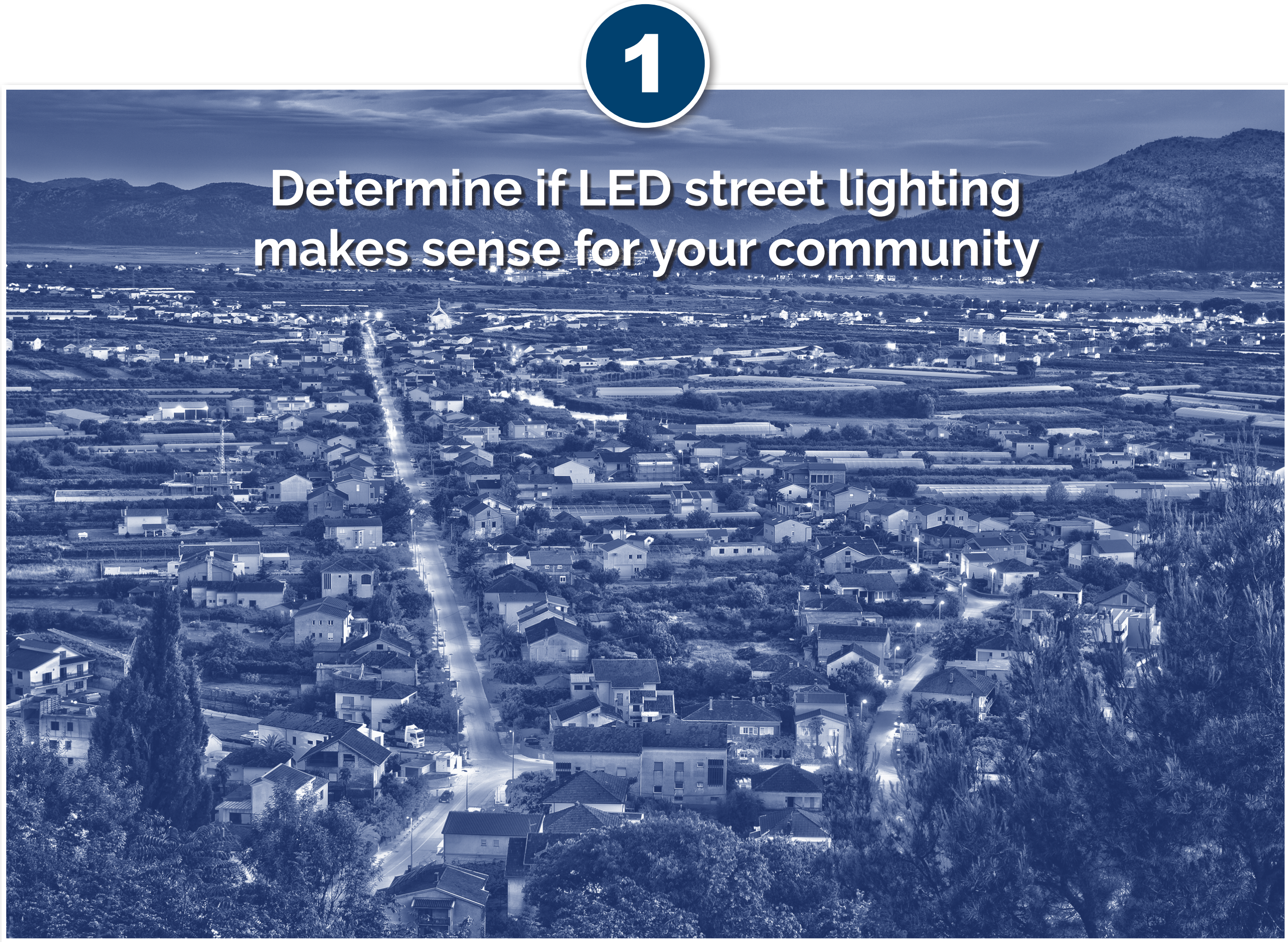
Benefits of LED Street Light Retrofit

Street lighting constitutes a significant portion of municipal energy consumption and expenditure. For many municipalities considering upgrades to their street lighting system, converting luminaires to LED has become the most viable option. In addition to environmental and economic benefits, undergoing a system-wide conversion can provide an opportunity for a municipality to standardize certain fixture types and styles, which can help create a unified aesthetic appearance or signature statement for a community.

Despite proven benefits and advantages offered by LED street lights, many cities may simply lack the personnel and resources to administer these projects. Like any project, a conversion to LED street lights will usually involve developing specifications, preparing bid guides, project implementation and oversight.

Benefits of LED lighting include:

- Energy and Cost Savings:
  - LEDs use over 50% less energy than the luminaires to be replaced (high-pressure, sodium lights).
  - LED luminaire pricing has decreased dramatically in the past 10 years and in most cases is lower than conventional HPS luminaires.
  - LED technology has improved in the past 10 years and has proven to be reliable, and long lasting, helping to dramatically reduce maintenance costs.
- Improved safety and security with enhanced visibility.
- Improved quality of light, with a variety of color temperature choices now available.
- Decreased light trespass and pollution.
- Opportunity to implement programmable ‘smart’ controls, either at the time of conversion or a future date.
- No mercury, lead, or other hazardous materials
- Instant-on.



The first step for any city considering converting their high pressure sodium or mercury vapor street lighting system to LEDs is to evaluate the actual data and draw on the experiences of other communities. Fortunately hundreds of communities throughout North America have already installed LED street lighting and there is considerable evidence thatLED street lights provide the following specific benefits compared to HID:

- Improved nighttime visibility and safety through better color rendering, more uniform lighting distributions and the elimination of many dark areas between poles.
- Reduced direct and reflected uplight: the primary causes of urban sky glow.
- 40-80% energy savings depending on incumbent lighting source and lighting design criteria.
- 50-75% street lighting maintenance savings.

It is highly recommended that cities begin networking with other cities who have installed LED street lights as early as possible in the process to help confirm the desired objectives and avoid pitfalls. A good starting place is the Municipal Solid State Street Lighting Consortium. The MSSLC is funded by the U.S. Department of Energy and is simply a consortium of communities who share experiences and best practices pertaining to LED street lighting. Visit their web site for more information:

http://energy.gov/eere/ssl/doe-municipal-solid-state-street-lighting-consortium

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Hold a kick-off meeting and form a project team

Completing an LED street lighting retrofit project will require support from multiple departments, and a well-balanced project team can be helpful to cultivate and maintain buy-in throughout the course of the project. Once a municipality has identified an interest in pursuing LED streetlight retrofits, it should hold a kick-off meeting to discuss the potential project scope with key stakeholders. These can include staff from the following departments, who should be invited to discuss their role in any potential project and to address any questions and concerns upfront:

- Public Works will need to be involved in providing information on existing street lighting infrastructure (condition/age, fixture type, maintenance requirements), as well as overseeing actual project construction.
- Engineering will need to be involved in assessing the feasibility of proposed retrofits.
- Planning/Community Development will need to be involved in classifying streets/ neighborhoods, identifying desired/appropriate lighting levels, and collecting public input on pilot programs.
- Administration/Finance will need to be involved in securing funding/financing for projects and approving final budgets and contracts.
- General Counsel will also need to approve contracts and should be engaged early on, particularly if they are unfamiliar with the procurement and contracting methods chosen.
- Procurement will need to be involved in identifying the appropriate procurement pathway for materials and labor, and putting projects out to bid.
- Energy Committee and/or Staff, if applicable, can be tasked with coordinating project team, summarizing research, and filling in staffing gaps as needed.
- Public Safety representatives may want to be engaged in the conversation as well.

Key decision points to be discussed with the project team and at the kick-off meeting include:

- Will there be a pilot program? At what stage in the project? How will the information be used?
- Will the team interview vendors on any state contract or approved material lists (AML) and bring back a report to present to the city council/board of selectmen?
- Who will decide the best procurement pathway?
- Will a lighting consultant be hired?
- Is funding available or is there support for a financing option?
- Will luminaires and labor be procured separately? What about design work?
- Should decorative/metered lights be included?
- Is there an interest in having controls, either at the time of the conversion or a future date?

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Define the scope of the project

In smaller communities it may be economical to convert all of the street lights at once. Larger cities typically find doing the project in stages is more practical. Defining the scope of the project is best done as follows:

1. Establish whether the entire lighting system is being retrofitted or just a small section, based on availability of funds.

2. Complete an audit of your current street light inventory and light levels. In many cases, cities do not have complete and current knowledge of the extent of their street lighting inventory. Ideally, this would include the following:
    - Every pole with GPS location.
    - Style of luminaire(s) on each pole (cobra-head, decorative acorn, decorative teardrop, etc.).
    - Lamp source and wattage of each luminaire.
    - Identification of responsibility for ownership and maintenance of each luminaire (city or utility).
    - Typical light levels and uniformity provided by each type of luminaire on each type of roadway. A lighting designer with roadway lighting experience or some street lighting manufacturers' representatives may be able to assist you with this if required.

3. Develop desired performance specifications for all of the streetlights that retrofits are planned for, based on the street lighting energy audit and/or improvement guidelines and ensure that the LED lights being considered have an adequate warranty that covers the product for a sufficient period of time

4. Decide on the controls for the LED technologies. The types of controls (basic photocells, motion sensors, dimmers, advanced panels) depend on the amount of flexibility desired for the different types of LED light uses. For example, a combination of motion sensors and dimmers could be implemented in parking garages, while solar-powered cells could be useful in emergency situations and grid outages.

5. If street lights are owned by an investor owned utility (IOU), confirm that they offer LED tariffs and/or rebates. This will substantially impact the financial viability of the project.

6. Evaluate the internal resources of the city to determine whether you have the capacity for a complete street lighting retrofit program. Most cities have done their relighting projects in stages. For example, the city might start with lower-wattage cobra-head products in areas with the greatest need for improved lighting. Unlike HID units, lower wattage LED lights are substantially lower cost than higher wattage units.

7. Due to high initial cost, replacing decorative lights typically offers financial returns substantially lower than cobra-head units, and consequently, are often deferred to later stages.

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Determine the source of funding

It is wise to carefully consider funding sources early in the process. The initial cost of LED street lights is still higher than HID lights and therefore they will typically take several years to pay for themselves in energy and maintenance savings. Some cities may simply choose to defer a conversion project. If a city lacks the resources to proceed with a street light conversion project, we recommend that the city consider a pilot program using various types of LED street lights from two or three different manufacturers to test. Many manufacturers offer special pricing programs for these test installations. By installing small quantity of LED street lights a city can quickly begin to educate itself on the technology, the mechanics of the products, the differences in the illumination quality, etc. Through this testing and evaluation, community feedback on light quality can be obtained. In the future, when you are able to proceed with this initiative, you begin with valuable experience versus starting from scratch. When you decide to move forward with the conversion, here are a few potential sources of funding to consider:

Self-Funding

If a city has its own municipal utility it may be possible to borrow the funds from the utility and pay it back over several years out of the savings in energy and maintenance.
With current interest rates, it may also be highly attractive to issue bonds or arrange financing through private capital markets. A variety of options are available to consider for financing a retrofit project:

- **Tax-exempt municipal lease financing** –This is the recommended method for paying for LED projects upfront, as it doesn't affect municipal bond rating or debt levy.

- **Performance contract** –With this method, guaranteed energy savings can be dedicated to debt service each year.

- **Bonds** – General obligation bonds and Qualified Energy Conservation Bonds (QECBs) are appropriate for projects with substantial up-front costs.

- **Operating funds** – If other energy projects have already been set up in the municipality and are generating savings, a case can be made to appropriate those savings for further energy efficiency improvements.

- **Capital projects** – An LED streetlight retrofit can be undertaken as a separate capital project, with a line item in the municipality's budget.

- **Grants** – Green Communities funds can potentially be used to cover the costs of acquisition, if acquisition costs are included as part of an overall funding request for LED streetlight retrofits. However, round 1 Green Communities funds can't be used to pay for streetlight retrofits. A municipality will have to wait for its next round of competitive grant awards to apply for any funding related to streetlight retrofits.

Federal Government

10 years ago many cities were able to take advantage of block grants in the 2009 American Recovery and Reinvestment Act (ARRA) for these projects. While this program has ended, cities may find other federal grants in the form of matching funds, etc.

State Programs

Many states have grants and low interest loan programs available for energy-saving projects.

Utility Programs

Utilities often have programs in the form of special tariffs, rebates and even turnkey installation programs.

ESCOs

Energy Service Company (ESCO) are now offering complete turnkey installation programs. They can finance the project as well as purchase and install the lights. The city can pay for this over many years out of energy and maintenance savings as well as any potential energy rebates.

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Complete a financial analysis

A preliminary analysis of the financial payback can be done quickly.

$$\frac{\text{Initial Cost of the Program}}{\text{Annual Savings in Energy and Maintenance}} = \text{Simple Financial Payback}$$

Example: Replacing (1,000) 100W HPS Cobra-head style street lights with $.10 kWh energy rate.

Initial Cost

- Cost of new LED luminaires = $230 X 1,000 = $230,000
- Cost of installation = (4 luminaires per hour installed at $200 per hour for two-person crew) $50 X 1,000 = $50,000
- Cost of bid, administration, misc. = $10,000
- Less utility rebates = $75 X 1,000 = ($75,000)
- Total Initial Cost = $215,000

Annual Savings

- Annual Energy Savings = 1,000 street lights X 4,000 hours per year X 75W per luminaire savings X .10 kWh rate = $30,000
- Annual Maintenance Savings = 1,000 street lights X $25 per fixture per year savings (assuming 4 year cycle of HID spot relamping, cleaning, changing igniters, ballasts, photocells, etc. vs. LED 10 year cleaning cycle and occasional photocell and driver replacements) = $25,000

Total Annual Savings = $30,000 + $25,000 = $55,000
Simple Financial Payback = $215,000/$55,000 = 3.91 years

Typically, programs with paybacks under 5 years should certainly be done and paybacks over 10 years are carefully considered. However, due to the urgency of global climate change, many communities (especially where the electrical energy source is fossil fuel-based) are proceeding with energy-saving programs that have very long financial payback periods. If the funding source is a federal or state grant, it will typically make sense for the city to proceed with the project with a long term payback period

If payback seems favorable, it is desirable to complete a more rigorous financial analysis to determine Return On Investment (ROI) and the Net Present Value (NPV) of the project. The US Department of Energy's Office of Energy Efficiency and Renewable Energy offers a more comprehensive on-line tool to help with these calculations:

http://energy.gov/eere/ssl/downloads/street-and-parking-facility-lighting-retrofit-financial-analysis-tool

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Consider the purchasing and installation process

Generally, the most cost effective method for these projects is for the city to buy luminaires directly and install them with their own crews or an outside contractor. However, some cities prefer the simplicity of having a single contractor provide a complete turnkey solution, which may also include financing, labor, warranties, etc.

This approach may require a longer financial payback period. Additionally, if a “turnkey solution” is chosen, and a municipality allows their contractor to make luminaire purchasing decisions, the contractor may choose to provide a lower quality street light. In this situation, it is imperative to list the acceptable products clearly in the bid guides (see Step 9)

Many cities find it helpful to network with other communities that have completed their LED conversions to aid in determining the best purchasing approach for them. For more detailed information on installation options see Section 11, Project implementation

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Consider "future-proofing" to accommodate intelligent controls

Lighting control standards and technology has evolved in the past 10 years. First generation LED luminaires were either unavailable with dimming drivers, or came at a substantial price premium. Today, the price adder for basic dimming capability is low. Some manufacturers even offer such capabilities as a standard feature on their lighting products.

In addition to dimming power supplies, in 2014 ANSI/NEMA published C136.41, a standard for a network lighting control receptacle. This receptacle, along with an industry-standard dimming power supply, enables luminaires to work with a variety of network lighting controls (NLC). Together as a system, NLC LED luminaires can provide asset management, energy saving, and other benefits.

Cities should work with lighting control companies to determine if the added cost and complexity make practical sense. At a minimum, cities should make sure they 'future-proof' their luminaire by specifying the industry standard receptacle and dimming driver.

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Develop a preliminary specification for the fixture selection process

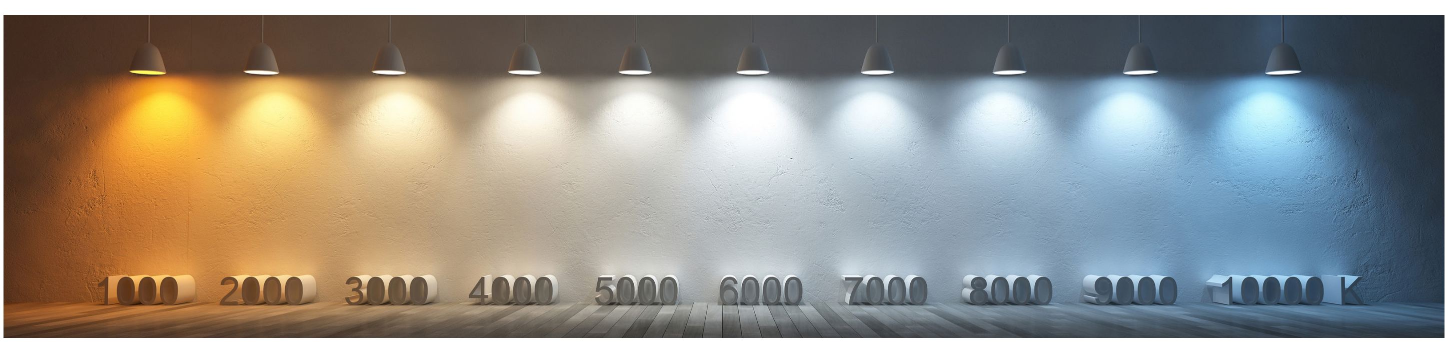
The following are important factors to consider in choosing fixtures for an LED street lighting conversion.

- **Equivalency** – When considering replacement fixtures for a street lighting system the aim is often finding "equivalent" fixtures to the existing ones that consume less power. This approach is relatively simple but assumes that the existing fixtures provide appropriate light levels. It also relies on judgments of equivalencies made by simply using source wattages and not required photometric performance. When evaluating proper replacement fixtures, some typical streets should be evaluated by comparing the LED fixtures under consideration with current lighting recommendations. This comparison can simply be done by performing lighting calculations for these streets showing expected results. These calculations can be performed by a lighting engineer or often can be provided by the manufacturer of the chosen lighting fixture(s). For simple equivalency cross-overs from legacy lighting to LED, manufacturers typically provide documents on ther websites to facilitate the process.

- **Expected life and performance** – LED fixtures are very different from currently used lamp technologies. The key in achieving system performance and expected life from LED fixtures is heat management. Heat is managed by the fixture design as well as the rating of the LEDs used and the current at which they are operated. For example, an LED that is operated at a higher drive current and having a higher output will lead to a less-efficient and shorter-lived LED and driver. When evaluating LED fixtures, refer to the following test reports:

- LM-79 - Electrical and Photometric Measurements of Solid-State Lighting Products: Provides the data on the photometric and electrical performance of the fixture under consideration.
- LM-80 - Measuring Lumen Maintenance of LED Light Sources: Provides and estimate of the expected life of the LEDs based on the lumen depreciation of the source.
- TM-21 - Projecting Long Term Lumen, Photon, and Radiant Flux Maintenance of LED Light Sources: Provides guidelines on the use of data compiled through LM-80 tests to assess the lifespan of a light source beyond the number of test hours recommended by LM-80.

- **Color** – Various products use LEDs that produce shades of "white" light. The color is a function of the phosphor coating used on the LEDs. The color is defined in terms of correlated color temperature (CCT). LED Street lighting fixtures are typically in the range of 2,700K and 5,000K, as illustrated below. To an observer, the high CCT sources will appear "cooler" with more blue content to the source, while the lower CCT sources will have a "warmer" appearance with more "red" content. Color preference is subjective, and many users decide on sources with a CCT of between 3,000K and 4,000K, depending on what is best suited for a particular application.



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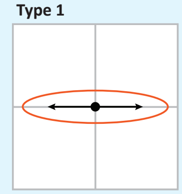
- **Generalized Distribution Types** Light distribution is basically the projected pattern of light that a fixture will disperse onto a surface. Actual Distribution Type is determined by peak intensity and "half max contour". Photometric tests assign distribution type based on this and actual distribution often varies substantially from these theoretical shapes. The IES defines a distribution type by where the maximum candela point and half max candela trace lie. While this approach appears to be rather abstract, it does give a good indication of the general distribution shape.

Distribution types are critical to mapping out a retrofit project and should serve as a starting point in project design and luminaire selection.

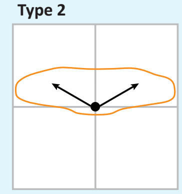
Type 1: Narrow, symmetric luminance distribution pattern. For median locations, popular for lighting walkways, paths, and sidewalks.

Type 1



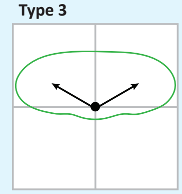
Type 2: Slightly wider, more symmetric luminance distribution pattern than Type 1, Generally used for ancillary roadways, also commonly used on larger walkways as it is applicable for a somewhat wider area

Type 2



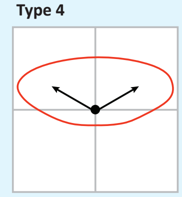
Type 3: Wide, asymmetric lumanance distribution pattern. Very commonly used in roadway lighting as it gives a bit more coverage further from the point source outward. Type III lighting is placed to the side of the area of illuminance, allowing the light to project outward and fill the area. Very popular in twin configurations.

Type 3



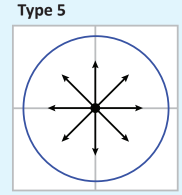
Type 4: Asymmetric, forward throw luminance distribution pattern. Generally used for intersections and parking lots with perimeter located poles or on the sides of buildings and walls..

Type 4



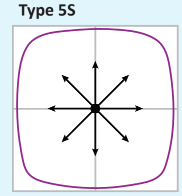
Type 5: Symmetrical circular luminance distribution pattern. Most frequently used when replacing HID lamps which are vertically oriented. Generally used for illuminating the inside portions of a parking lot or a 4-way intersection.

Type 5



Type 5S: Symmetrical nearly square luminance distribution pattern. Most frequently used when replacing HID lamps which are vertically oriented. Also used for illuminating the inside portions of a parking lot or a 4-way intersection.

Type 5S



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- **Construction** – Material and construction is indicative of the expected life of the fixture. Reviewing available test reports for the fixture can offer an idea of the quality of construction. Tests which should be available for review include salt spray or salt fog testing, vibration testing, and the IP testing report, which rates the Ingress Protection of the LED "Light Engine" against solids and liquids. An IP designation typically uses two digits to identify the amount of protection a fixture has, with higher numbers noting greater protection. Roadway LED Light Engines are typically rated an IP65 (with the 6 meaning totally protected against dust and the 5 meaning that it is protected against low pressure jets of water from all directions – limited ingress). Surge suppression is an important option for solid-state devices like LEDs, and many fixtures can provide surge suppression of up to 20 kV. The fixture warranty can also give some indication of the construction. Most LED streetlights are available with at least a five-year warranty, with some offering a ten-year warranty.

- **Optical Control** – Optical control is an important factor to consider, particularly relating to lighting trespass, sky glow, and glare. Lighting calculations will quantify these impacts for the fixture under consideration. Another means is the BUG rating system developed by the IES. This system classifies the amount of Backlight, Uplight, and Glare they produce. The higher the BUG rating, the more of each of these items they produce. The correct BUG rating for an installation depends on many factors. Typically, ratings of B2-U0-G2 have been found to be acceptable.

- **Style and Finish** – LED fixtures come in various styles, ranging from contemporary to utilitarian to period reproduction styles. Before selecting a style, evaluate higher-volume streets like a downtown area and decide whether a unifying style or color may assist in creating an image or place within the community. The investment in a lighting retrofit can provide benefits beyond energy and maintenance savings and should be considered as part of the community planning and development process.

- **Model Specification for Networked Outdoor Lighting Control Systems -** The DOE Municipal Solid-State Street Lighting Consortium's Model Specification for Networked Outdoor Lighting Control Systems helps cities, utilities, and other local agencies accelerate their adoption of systems that can further reduce the energy and maintenance costs of operating their streetlights.

https://www.energy.gov/eere/ssl/model-specification-networked-outdoor-lighting-control-systems

7

Minimum Specification: Example

EXAMPLE: LED "Cobra-head" Style Luminaire Preliminary Specification

This basic, eleven-item specification would normally eliminate very poor quality products and unreliable suppliers. All major U.S. manufacturers with significant experience in LED street lighting should easily meet this specification.

I. Luminaire shall mount to a 1¼" to 2" (1⅝ " to 2⅜" O.D.) diameter mast arm.

II. Luminaires shall have an Effective Projective Area (EPA) not to exceed the EPA rating of the luminaire being replaced.

III. EMI meets or exceeds FCC 47 CFR Part 15. Transient voltage complies with ANSI C62.41 Cat. C High.

IV. Luminaires shall pass the 3G vibration test per ANSI C136.31-2001.

V. Paint finish shall equal or exceed a rating of six per ATSM D1654 after 1000 hours of salt spray testing per ASTM B117.

VI. Luminaires shall produce 0 light at or above 90°.

VII. Luminaires shall be qualified by the DesignLights Consortium.

VIII. Luminaires shall be listed by a Nationally Recognized Testing Laboratory as suitable for wet location applications.

IX. Manufacturer shall provide a minimum ten-year limited warranty.

X. Luminaire shall have a have a 7-pin photo control receptacle that meets ANSI C136.41.

XI. Luminaires shall meet the lighting levels and uniformity requirements shown in the scenarios below:

Scenario A

Replacing 100W HPS luminaires in local/residential applications with a low pedestrian conflict classification

Road width: 40'
Pole Mounting Height: 25'
Pole Spacings: 150' Single Side of Street
Mounting Arm: 8'
Pole Set Back from Street: 2'
Light Loss Factor in Calculations: .85

Minimum Required Average Illuminance: .4 fc
Average to Minimum Uniformity: 6 to 1

Scenario B

Replacing 150W HPS luminaires in collector/commercial applications with a medium pedestrian conflict classification

Road width: 55'
Pole Mounting Height: 30'
Pole Spacings: 175' Single Side of Street
Mounting Arm: 8'
Pole Set Back from Street: 2'
Light Loss Factor in Calculations: .85

Minimum Required Average Illuminance: .9 fc
Average to Minimum Uniformity: 4 to 1

7

Minimum Specification: Example (Continued)

I. **Luminaire shall mount to a 1¼" to 2" (1⅝ " to 2⅜" O.D.) diameter mast arm**
This is the standard range of pipe sizes to which both HID or LED "cobra-head" style fixtures mount.

II. **Luminaires shall have an Effective Projective Area (EPA) not to exceed the EPA rating of the luminaire being replaced.**
This specification assures that the wind load rating of the luminaire won't be larger than the replacement HID cobra-head and potentially compromise the pole. Typically, luminaires with an EPA at or below .9 ft2 will comply with this.

III. **EMI meets or exceeds FCC 47 CFR Part 15. Transient voltage complies with ANSI C62.41 Cat. C High.**
This is an FCC requirement to make sure that the electronics in the luminaire won't interfere with broadcast or cable systems, etc.

IV. **Luminaires shall pass the 3G vibration test per ANSI C136.31-2001.**
This is the industry standard test to ensure the luminaire will remain on the mast arm despite normal vibrations.

V. **Paint finish shall equal or exceed a rating of six per ATSM D1654 after 1000 hours of salt spray testing per ASTM B117.**
This is especially important in coastal regions to ensure that the finish won't fail, resulting in premature corrosion of the housing.

VI. **Luminaires shall produce 0 light at or above 90˚.**
With traditional HID cobra-heads there was a trade-off between drop refractor type lenses and flat glass lenses (previously classified as "full cutoff"). Drop lens units typically produced wider pole spacings and more uniform lighting patterns. Flat glass units typically had less uplight (which contributes to sky glow), better control of light trespass into residential windows, and lower high angle glare. One of the great benefits of LED lights is that you can now "have it all". With the precise optical control capability of LEDs, it is now possible to achieve the uniformity and spacings of the HID drop glass units while achieving controls associated with flat glass units: eliminating direct uplight and light trespass and reducing glare.

VII. **Luminaires shall be qualified by the DesignLights Consortium**
The DLC is a consortium of utility companies and regional energy efficiency organizations that evaluate luminaire manufacturers' LED data (LM-80), and their in situ thermal tests. If the manufacturer provides product data to the DLC and it demonstrates that the product meets the DLC criteria for projected LED life, the DLC will add the product to their list of qualified products. By adding this to the specification, the municipality is relieved of the burden of having to obtain and evaluate the data. DLC qualification is usually required to qualify for most utility programs or rebates.

Note: Neither Lighting Facts nor the DLC evaluates actual products and their listing provides no assurance of product quality in areas such as meeting desired lighting levels, mechanical features, etc.

Minimum Specification: Example (Continued)

VIII. Luminaires shall be listed by a Nationally Recognized Testing Laboratory as suitable for wet location applications.

Requiring a label from UL, ETL, or CSA, etc. assures that the product has passed industry standard tests for product safety. The thermal and environmental tests performed for wet location rating assures the product was suitably designed for outdoor applications. Also, the National Electric Code requires electric lights to have this label.

IX. Manufacturer shall provide a minimum ten-year limited warranty.

The warranty should cover the entire luminaire - especially failures of the LEDs (usually 10% or more LED failures constitute a luminaire failure), power supply, and paint finish. The industry standard today for LED street light warranties is 5 years. Many manufacturers may be willing to offer longer warranties, but they will usually charge a premium for this. Specifiers should consider manufacturers who offer the longest warranty without additional cost.

X. Luminaire shall have a have a 7-pin photo control receptacle that meets ANSI C136.41

See Page 10, Step 6 "Consider options for a control or monitoring system" for explanation.

XI. Luminaires shall meet the lighting levels and uniformity requirements addressed in the scenarios above:

It is a good idea to specify some application-based lighting criteria.

The scenarios listed are typical but are by no means standard. It may be useful to simply list these scenarios in the initial specification, but it would normally be preferable to replace the values in bold underline with the actual mounting heights, pole-spacings, etc. that exist in your community. To create the design to verify the lighting criteria is achieved by each manufacturer, the same LM-79 IES file should be used that was submitted to gain listing by Lighting Facts.

This is the industry standard for lighting roadways. However, many communities today do not light to this standard. Also, if these values are not being achieved currently with HID lights, it may not be realistic to achieve these lighting levels when converting to LEDs. Those communities instead typically try to achieve light levels that are as good as or better than what had existed with the incumbent technology.

8

Product selection

Contacting manufacturers and inviting them to present their luminaire offerings and technical data is very important. Wherever possible, it is also advisable to include invested departmental leaders in these meetings.

Generally the most successful LED street lighting conversion projects have been in cities that began dialogues with several manufacturers early in the process, inviting them to present their products and photometric analysis to determine:

1. Compliance with the spec
2. Visual product quality
3. Apparent ease of installation and maintenance
4. Experience, integrity, and solvency of manufacturer

In addition, it is recommended that local lighting representatives be encouraged to bring in any additional luminaires which comply with the preliminary specification. As with most solid state technologies, products are constantly introduced that offer new features. It is wise, however, to consider the stability and experience of the manufacturer when evaluating quality, service capability, and value of the warranty.

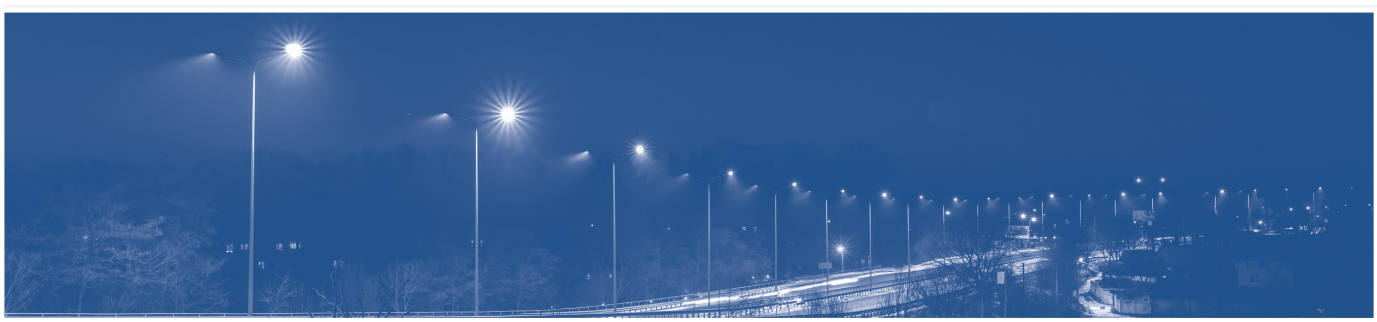
9

Test and evaluate the preferred luminaires

Based on the results of the preliminary evaluation in Step 7, it is a good idea to identify between three to five potential manufacturers whose products met the specification and offered desirable mechanical or performance features. These might include things like tool-less access to the electrical compartment, appealing daytime form, or new, higher-efficiency LEDs.

A good location for a street light test is a low-traffic residential location with existing 70W or 100W HPS cobra-heads, consistent single-sided pole spacings and minimal trees. After this area is identified, invite the selected manufacturers to run the lighting calculations with their product IES files for your test installation (1.0 light-loss factor to facilitate verification) using the precise street width, pole locations and mounting height. The proposed products should meet your lighting design criteria, such as RP-8, or your existing HID light levels for this application.

Many manufacturers have discount programs to sell a few street lights for these types of test installations. It is recommended that four luminaires from each manufacturer be purchased. These samples should be visually evaluated prior to installation for any damage that may have occured during shipment. Particular attention should be given to packaging used for shipping and safe transport to the installation site. Insufficient pacakging may lead to damage during transport, while excessive packaging may slow down the installation process, as extra trips will be required to return carton material for recycling and pick up additional luminaires.



After inspecting the sample products, replace four adjacent HID luminaires with the four purchased products and repeat for all of the manufacturers in the test location. If possible, test for the actual power consumption (system watts) of each of the units prior to, or during installation.

To test lighting performance use a light meter designed to read measurements to .01 fc to take measurements at four locations: at grade below the luminaires, across the street from the luminaires, at the point between the luminaires, and the opposite side of the street from the midpoint of the luminaires. Compare these values to the manufacturer calculations. This will allow you to confirm the manufacturer calculations and to evaluate the energy use and efficiency of each light. The most important metric of efficiency is the wattage required to provide the desired light levels. In other words, “footcandles on your street per watt” is more important than “lumens per watt”.

There is also a strong subjective element to street lighting and it is very wise to obtain input from everyone involved in the project. After the test units are installed, invite feedback from city councils, public works departments, maintenance departments or installing contractors, local citizens, etc. on ease of installation, quality of illumination, light trespass, glare, and other issues that are deemed important.

Based on the results from the test installation, select the products that are acceptable. Now writing the specification becomes very simple. You can use the original preliminary specification and simply add the selected manufacturer names and part numbers. Generally speaking, the more products you allow, the more favorable the pricing will be. Therefore, you should certainly list at least two products. Federal contracts may require at least three. It should be added in the bid guides that no other products will be considered since you have completed your evaluation.

If the decision in Step 5 was to purchase the luminaires directly, using the city's own crews for installation, the Request for Quote (RFQ) will be for luminaires only. If an outside contractor is being used, there will need to be a separate RFQ for "installation labor only". Finally, if a contractor is being selected for a complete, turnkey installation, a single RFQ can be issued for furnishing and installing the luminaires.

If there is a significant preference for one or more of the "acceptable" luminaires, it may be desirable to develop a "weighting point system" where price is only one of the factors in selecting the luminaire. Additional weight can be given to specific product features, application efficiency (footcandles on the test area), manufacturer experience, etc. This would allow the flexibility to purchase the luminaire with the preferred features if it is only slightly higher-priced than the unit with the lowest bid. If your utility offers a "turnkey option", it is usually wise to get a competitive bid as their programs can be quite expensive.

It is usually a good idea to include a reasonable delivery requirement in the RFQ as well (e.g., "Luminaires shall be delivered to the City Maintenance Yard within 60 business days of project award"). During the preliminary product evaluation phase, you can simply ask the suppliers what their typical delivery would be on the quantity on the RFQ. Similarly you can informally survey local contractors to determine what kind of a schedule they would normally require for this type of project.

Based on how you structured your awards (material-only point system, furnish and install, etc.), you should issue the award after you have completed the evaluation of the bids per your normal award process.

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Project implementation

After establishing a clear project scope, cost, and timeline, the implementation phase can begin in earnest. It is helpful to maintain a checklist of tasks, responsibilities, and milestones to ensure that all aspects of the project are progressing as required. Some important components to consider are:

- Design/audit work
- LED luminaires: types, purchase costs
- Installation labor
- Maintenance and performance verification
- Submission for utility for incentives

If the city's own crews are doing the installation this will obviously require more oversight than if an outside contractor is used. Some cities have used a combination of their own personnel and an outside contractor to install luminaires. Based on cost and project schedule this can add significant flexibility to the project.

Networking with other cities who have had similar projects can provide a good basis for evaluating the number of installs per day that should be achieved. In addition, they can be an excellent source for suggestions on creating the most efficient crews, staging material, etc.

Establishing a realtionship with the luminaire manufacturer is also a key element for success. It is highly recommended to have a meeting with the manufacturer (or their representative) and the contractor (if applicable) immediately after the award. An additional luminaire sample should be provided at that meeting representing the exact model that will be furnished on the job. This should include any special wiring configurations, paint finish, labeling, accessories, carton, etc. This will avoid any misunderstanding of exactly what is being ordered and delivered.

A realistic schedule should be developed that will allow the manufacturer to deliver the products consistent with the city's ability to have them installed. Often on large projects, storage is a critical issue. If the project becomes delayed due to weather or other unforeseen circumstances and the city does not have the facilities to store the luminaires, contingency arrangements should be made.

If the installation work is going to be performed by a contracted installer or potentially by multiple installers (e.g., when installers are allowed to bid on portions of the work, even if one wins everything), municipalities should consider some of the following questions:

- What type of experience does the respondent have working with municipal street lighting systems?
- How many years has the respondent been engaged in providing energy efficiency, street lighting, and performance contracting services?

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Project implementation

- Do the respondent’s maintenance and installation employees have any accreditations or pre-qualifications?

- What scope of services (auditing, design, construction, monitoring, operations, maintenance, training, financing, etc.) does the respondent offer? In particular:
  - Does the respondent offer services to upgrade the following: street lighting, controls, underground feeds, overhead feeds, foundations, pole placement, series circuits, parallel circuits, emergency response, call center operations, and other street lighting systems?
  - What is the respondent’s general knowledge of latest street lighting technologies and associated life cycle costs?
  - What is the respondent’s general ability and approach to help with financing and secure low rates?
  - What is the respondent’s general ability to secure insurance policies?
  - Does the respondent operate a 24-hour call service with a toll-free number answered at all times by a person to receive outage reports with the capability for real-time work order dispatching for emergency calls? If so, for how long has it been in operation?

- Which of the respondent’s past project experiences involve systems similar in type, size, or scope of the project?

- What are the respondent’s relationships with lighting fixture, controls, and other related technology suppliers?

- What are the respondent’s staff capabilities in terms of conducting technical analysis, engineering design, construction management, construction, training, and post-contract monitoring?

- What scope of services (auditing, design, construction, monitoring, operations, maintenance, training, financing, etc.) is the respondent proposing? What is the respondent’s approach to auditing streetlights and determining light output?

- Does the respondent have facilities management and maintenance personnel to coordinate installation and avoid conflicts with other ongoing or scheduled projects?

- Will the respondent use subcontractors, and if so, in what nature?

- What is the proposed project schedule?

- Does the respondent assume all responsibility for proper handling, storage and disposal of environmentally sensitive equipment?

- What equipment ownership model does the respondent propose? What is the respondent’s proposed service responsibility?

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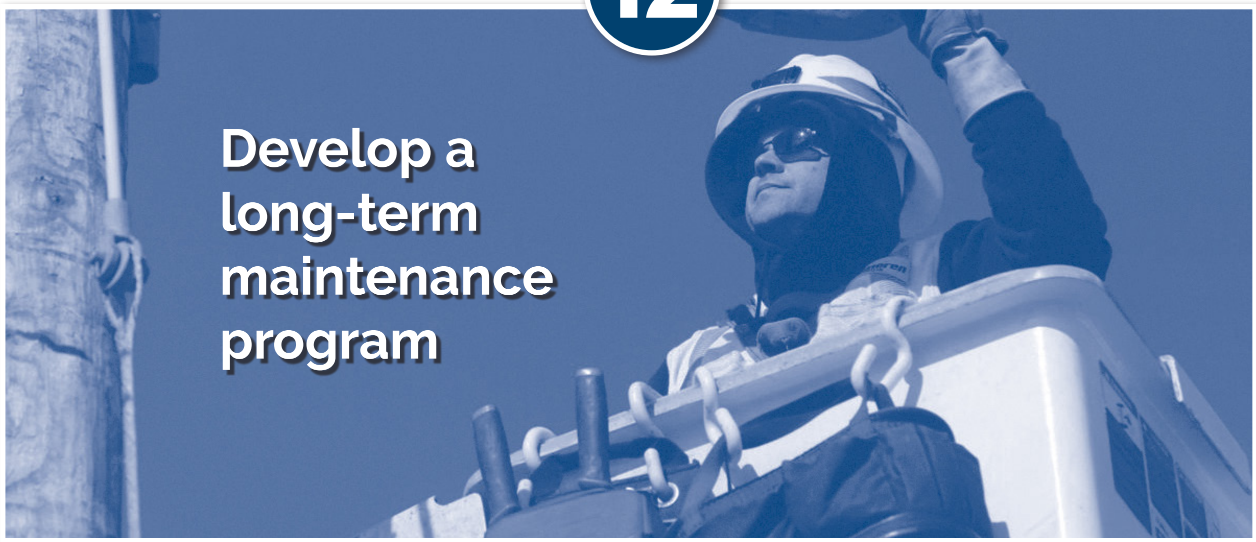

Unlike traditional HID lamps, LEDs don't typically fail by "burning out" after some period of time. Rather, over long periods of time, LEDs will gradually become dimmer. Regardless, the better LEDs used in street lights on the market today may still be producing over 90% of their initial light after 100,000 hours in the field (25 years in typical applications).

Although it is impossible to predict the lighting technology in 15-20 years, the LEDs on the market today will no longer be available. We can reasonably assume if LED lights need to be replaced, the light source products on the market in 15+ years will be considerably more efficient, physically different, and not mechanically compatible with current luminaires. Consequently, it really doesn't make sense to plan for "changing light bulbs" as you would for HID lamps. Therefore, there is no practical advantage to specifying "replaceable LEDs" or "modular light engines", etc. At some point, it will simply make economic sense to replace the entire luminaire with the latest technology product available.

Given the very long life of LEDs, there is a paradigm shift on how we consider designing a long-term maintenance program. There are two major issues worth considering: 1) Spot replacement of components, and 2) Luminaire cleaning.

Spot Replacement of Components

HID systems have failures of lamps, igniters, ballasts, and photocontrols. In LED systems, only power supplies (drivers), surge protectors, and photocontrols are typically subject to replacement. Today's power supplies are commonly rated for 100,000 hour life and the expectation is that replacements will be very rare: probably less than 1% over the life of the system.

Because of the projected long life of these systems it may not be practical to stock replacement "power supplies" or "power doors". The entire luminaire is typically covered by the manufacturer's warranty for the first 5 years or longer, so it makes sense to replace the complete unit in the event of an occasional failure. Also, this will allow the greatest flexibility when different manufacturers or different product generations are used in the city.

There are also now "long life photocells" on the market designed to last up to twenty years. While these have a considerable price premium over conventional photocontrols, it may be a worthwhile investment since they don't have to be replaced as frequently.

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LED Street Lighting requires less maintenance and offers reduced costs due to longer life and higher efficiency. However, all luminaires, require periodic cleaning to maintain the quality of light.

Luminaire Cleaning

Like all luminaires, LED street lights are subject to dirt build-up that will depreciate light output over time. Unfortunately, because LED street lighting is still relatively new, there is no extensive field data that would prescribe a precise cleaning program for various environments. Much less heat is generated on the lenses by LEDs than HID lamps, so less dust will normally adhere and fuse to the lens than has been experienced in outdoor HID luminaires. For this reason, we would expect to see considerably lower Luminaire Dirt Depreciation (LDD) on LED luminaires.

Given the lack of data regarding the necessity for cleaning luminaires, a reasonable program is suggested:

1. As soon as luminaires are installed, check the light levels directly below the luminaires at grade at several pole locations. For accuracy, it is advisable to use a light meter designed to read measurements to .01 fc. Log this data.

2. Recheck light levels on an annual basis and at the exact locations. Compare the data.
   - Try to test at the same time of year to avoid any discrepancy caused by temperature.
   - LEDs will often increase their light output before they begin their depreciation so it is not uncommon to see higher readings one year after installation.

3. After a few years, when the light levels have dropped by more than 10%, try a high-pressure wash on the lens from the ground and then recheck the light levels. If there is no significant improvement, it may be necessary to visit the luminaires and wash the lenses with a wet cloth.

4. Continue to check the light levels periodically and ultimately implement a luminaire cleaning program based on the frequency required to maintain the desired illumination levels.

Common Street Light Fixture Types

- **Incandescent** lights are the most out-dated and least efficient street lighting technology available, although utilities currently maintain a tariff for incandescent lights.

- **Mercury vapor (MV)** lights replaced incandescents in the '50s and continue to be a widely used technology today.

- **High-pressure sodium (HPS)** lights are the most commonly used technology by municipalities today. A typical 150W HPS fixture:
    - Draws an average of approximately 183W of power
    - Has a CCT of 2,000K
    - Has a CRI of 22

  (Note: Low-pressure sodium lighting is also used on rare occasions. It is more efficient but the color rendering is worse than HPS.)

- **Metal halide (MH)** lights are also a commonly used lighting source. This lighting technology emits a very bright white to bluish light. The color of these lamps tends to shift over time. It is not uncommon to find a row of identical MH fixtures with each emitting slightly different color light. A typical 175W MH fixture:
    - Draws an average of approximately 208W of power
    - Has a CCT of 4,000K
    - Has a CRI of 65

- **Induction lighting** transfers electric power via electromagnetic fields, rather than electric connections (electrodes). It is a more efficient method of transforming electric power into light. Induction lamps are also referred to as electrode-less lamps. Current technology of induction lighting provides a much higher color temperate and yields a cooler/bluer light than HPS lamps.

- **Light-emitting diode (LED)** This technology can provide directional light emission and has a longer life than conventional light sources. In comparison to HPS and MH technologies, LEDs are also improving more rapidly in terms of color quality, optical design, thermal management, and cost.

Incandescent

Mercury Vapor

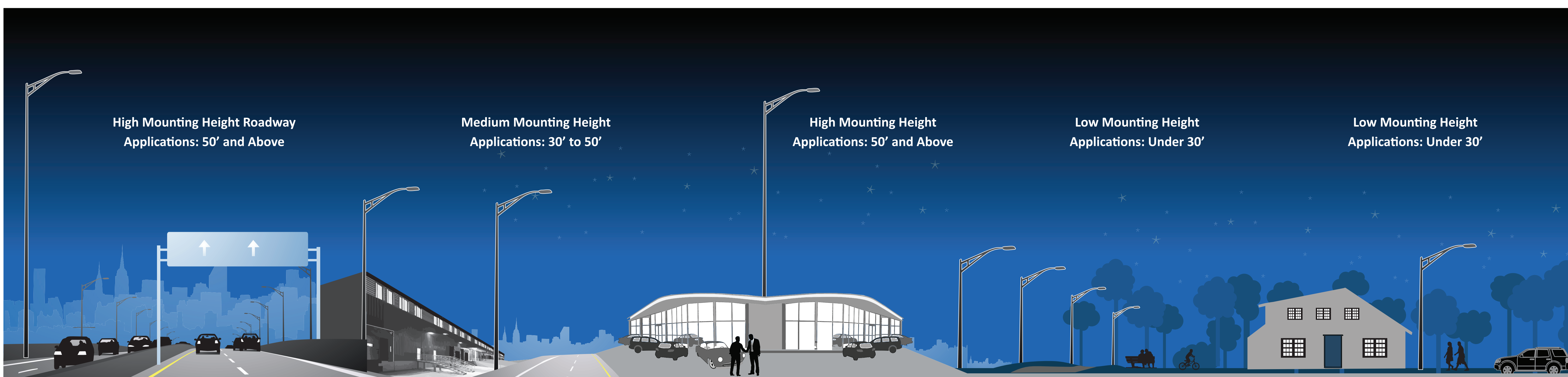
High Pressure Sodium (HPS)

Metal Halide

Induction

Light Emitting Diode (LED)

Typical Street & Outdoor Lighting Applications



Resources

Municipal Solid State Street Lighting Consortium

http://energy.gov/eere/ssl/doe-municipal-solid-state-street-lighting-consortium

Illuminating Engineering Society:

RP-8 – Guide to Roadway Lighting is available for purchase in both print and electronic versions

http://www.ies.org

DesignLights Consortium

http://www.designlights.org

Underwriters Laboratories

https://ul.org/

California Lighting technology Center

https://cltc.ucdavis.edu/

Pacific Northwest National Laboratory Advanced Lighting

https://www.pnnl.gov/advanced-lighting

Helpful information on outdoor lighting and LED color temperature:

US Department of Energy: LEDs and color temperature, as well as other topics:

http://www1.eere.energy.gov/buildings/ssl/pdfs/true-colors.pdf

The US Department of Energy, through its SSL 'Postings' newsletter:

http://energy.gov/sites/prod/files/2016/06/f32/postings_06-21-16.pdf

The Illuminating Engineering Society of North America (IESNA), through a statement on a preliminary review of the AMA policy statement and report:

http://ies.org/emails/2016/june/ama-response.html

The Lighting Research Center (LRC), through a press release on its website:

http://www.lrc.rpi.edu/resources/newsroom/pr_story.asp?id=320#.V7ztGhQdeke

We welcome your questions and feedback.

If you would like to contact a Leotek Regional Sales Manager for your area to discuss your project or address specific questions, please visit the sales contact page at:

https://leotek.com/commercial-municipal-dot-sales/

For product information and specifications:
www.leotek.com

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With ongoing research and development, continuous improvement of existing products, and the introduction of innovative new products, Leotek is committed to developing solid-state technologies that are reliable, long-lasting, and energy efficient.

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