CURRENTS

AN ENERGY NEWSLETTER FOR LOCAL GOVERNMENTS

Light Up Your City!

STREET LIGHTING

Data from the California Energy Commission indicate that about 20-25% of California's municipal energy expenditures go to pay for streetlighting. How local governments choose to light streets, neighborhoods and community spaces has a significant impact on how much energy communities use, as well as on municipal budgets.

As any lighting engineer will tell you, outdoor lighting is a complicated topic. There is more than one way to light a street or a neighborhood, and lighting choices affect neighborhood ambience and safety.

This special edition of *Currents* is designed to give you some background on currently available technologies and practices, as well as access to resources to find out more. Kristina Kaufmann served as principal researcher and author.

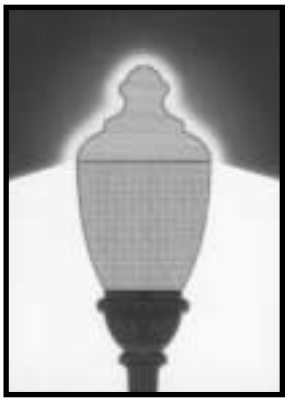
SPECIAL EDITION

WHAT'S INSIDE

Starting from the Top – Lamps

From an energy efficiency standpoint, the most critical issue is light source. A streetlamp's energy efficiency is largely determined by the amount of light produced (or lumens) per watt, as well as the fixture and optics for housing the lamp and modifying and directing the light it produces. New lighting technologies have been developed which are much more energy efficient than they were when electricity was first used to illuminate streets about one hundred years ago.

The quality and brightness of light produced is another critical factor. The mood of a neighborhood can be altered, for example, by choosing lamps which give off a white glow or an orange glow, or by choosing to use no lights at all. The ability to distinguish colors under various types of lighting may impact the safety of some pedestrians wearing certain colors or hamper the identification of crime suspects.



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Five Lamp Options for Street Lighting

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Five options for streetlighting – mercury vapor, high pressure sodium, low pressure sodium, metal halide, and induction – and issues relating to the use of these lighting systems are highlighted in this issue.

1 • Mercury Vapor

Once commonly used for outdoor streetlighting applications, the mercury vapor lamp is the least energy efficient option currently available. Developed in the 1950s, mercury vapor lamps provided at the time a highly efficient alternative to incandescent lamps by producing twice the amount of light using the same amount of electricity. The mercury vapor lamp has since become outdated in energy efficiency terms by at least 50% when compared to new lighting options. Other more efficient white light sources such as induction or metal halide lamps could easily replace mercury vapor lamps with little change in light quality.

While mercury vapor lamps were once the industry standard, they have been replaced for the most part by high-pressure sodium and, in some cases, low-pressure sodium lamps.

2 • High Pressure Sodium

High pressure sodium lamps (HPS) are the standard streetlighting option today. First widely used during the energy crisis in the early 70s due to its energy efficient nature, HPS still offers an efficient lighting option. Cities installing HPS streetlighting systems can expect a payback period of six years given the resulting energy savings. Several lighting companies manufacture usable wattage HPS lamps.

3 • Low Pressure Sodium

Since the late 1970s, low pressure sodium lamps (LPS) have offered a more energy efficient alternative to high pressure sodium lamps. LPS lamps were specially designed to maintain luminance over the lamp's lifetime and to operate at low temperatures. Safety and aesthetic concerns sometimes arise out of the LPS' poor color rendering abilities. The orangish-yellow hue from these lamps makes it difficult to distinguish the true colors of objects. Compared to other lighting options, the monochromatic yellow light of LPS lamps can be easily filtered out by telescopes and is, therefore, the favored lighting system near observatories. LPS lamps require special fixtures because the lamp's light is hard to control.

Laboratory test data show that human eyes need light in the blue wavelengths to perform depth perception well – precisely the portion of the lighting spectrum in which both low and high pressure sodium perform very poorly. As such, lighting levels of sodium lights may need to be raised to perform as well as lower wattage, wider spectrum white lighting such as metal halide and induction.

Reactions to HPS/LPS streetlights vary, as Long Beach, CA (see p. 4), and Tucson, AZ (p. 8), have found.

4 • Metal Halide

Metal halide lamps are twice as energy efficient as the mercury vapor lamps they often replace. Light is produced as an electric current flows through gas within the lamp. They provide a bright white light and are often used to light parking lots and sports arenas. They are also utilized where color rendering is crucial. Metal halide lamps burn very hot and unless the ballasts are widely separated from the lamp they can burn out quickly, causing them to be high

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Lamp Efficiency and Life Spans

Type of Lamp	Lumens per watt	Average Lamp Life (hours)
Mercury Vapor	13-48	12,000-24,000+
High Pressure Sodium	45-110	12,000-24,000
Low Pressure Sodium	80-180	10,000-18,000
Metal Halide	60-100	10,000-15,000
Induction	61-76	100,000

☞ In California, street lights are lit on average 4,100 hours per year.

Induction Lighting Is A New Alternative

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maintenance lamps. The brightness of the lamps creates a high glare potential.

5 • Induction Lighting

A new alternative for street-lighting is a type of light generation based on induction, the transmission of energy via a magnetic field combined with a gas discharge. It offers consumers an energy efficient white lighting option with long life. It is a softer, non-glary light and, therefore, works well in low-mounting height situations. With a 100,000-hour life span, the induction lamp far surpasses all other lamp types (which last on average 10,000-30,000 hours). Induction technology has been available for only six years (compared to the 20-30 years of sodium lamps) and has an expensive initial cost. In most cases, however, reduced maintenance costs over the bulb's life will offset the additional cost of the initial system. Some distributors feel a shorter life bulb is better because other components are likelier to fail or degrade first. Maintenance may thus be delayed and performance suffer because the bulb doesn't fail often enough to bring the maintenance people around. Induction lighting is widely used in Europe, especially in shopping centers.

The Pros and Cons of Lamp Options

■ MERCURY VAPOR

Inexpensive to install and purchase	Expensive to operate due to inefficiency
Medium life	Tend to be glary due to intense light
Dimmable	Dramatic lumen depreciation over time
Good color rendering due to white light	Use hazardous material (mercury)

■ HIGH PRESSURE SODIUM

Energy efficient	Orangish-yellow light
Widely used, reliable	Safety concerns due to color rendition
Medium life	Can not restrike immediately

■ LOW PRESSURE SODIUM

Very energy efficient, medium life	Orangish-yellow color
Minimum glare	Safety concerns due to color rendition
Able to restrike immediately	Expensive fixtures
Do not attract most insects	

■ METAL HALIDE

Good color rendering	Short life, high maintenance
More efficient than mercury vapor	Less efficient than HPS, LPS and Induction
Widely used	High temperatures burn out ballasts

■ INDUCTION LIGHTING

Energy efficient	High initial cost
Low maintenance costs due to long life	Difficult to retrofit existing fixtures
Good color rendering due to white light	Use small amounts of mercury
Immediate ignition & re-ignition	Not dimmable
No flickering	Need a high-frequency generator

Both Philips Lighting and Osram Sylvania Lighting companies have developed marketable induction lighting systems. The Philips QL Induction lamp comes in 55W, 85W and 165W bulbs. The Osram Sylvania Icetron Induction lamp comes in the following bulb/generator configurations: Icetron 100/QT 1X100, Icetron 100/QT 1X150, or Icetron 150/QT 1X150.

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Lighting and Livability

The choice by local governments and developers to use one lighting approach over another will create different night-time ambiances. The mood of a neighborhood can be altered, for example, by choosing lamps which give off a white or orange glow, or by choosing to use no lights at all. The height and design of poles and fixtures can also affect the feeling people have when traveling in a neighborhood. Shorter, closely spaced poles provide a more pedestrian-friendly atmosphere than widely-spaced lamps mounted at higher levels.

Cost, engineering and aesthetics come into play when selecting a streetlight type. Factors to consider include:

- Safety. Will there be enough light for pedestrian and vehicle traffic? Will pedestrians feel safe walking down the street?
- Costs. What are the first costs? Energy costs? Maintenance costs?
- Glare. Will it impact the ability to see comfortably, to avoid accidents and blind spots?
- Light Trespass. Will it be a nuisance to residents and waste energy by not keeping light in the needed area?
- Uplighting. Will it intrude upon the night sky and waste energy by not directing light downwards?
- Light Quality. Will it be too bright, or not bright enough? Will it difficult to distinguish colors?

You can light a space different ways. You can use either one high, bright light source or several lower, dimmer light sources. If streetlight spacing is coordinated with other elements of the street (such as trees, parking, and storefronts), the resulting order strengthens the subtle perception of the streetscape as an intentional public living room.

Post-top lights are the most traditional and "pedestrian-friendly" option. Because they are lower in height, closer to the eye, and occur within the vertical visual field, post-top lights typically must use lower wattage lamps (to avoid glare) than taller cobraheads and shoeboxes. 13-foot high, post-top-mounted streetlights produce a pleasing and supportive pedestrian environment. The pole is short enough to be within the scale of the human body and to create a "ceiling" for the outdoor "room," yet tall enough to be a substantial presence on the street.

By comparison, cobraheads and shoeboxes use more powerful light sources spaced farther apart, reducing equipment and fixture costs per linear foot. Taller and less ornamental poles are better suited for highways and locations at which walking speed and pedestrian contact are not issues. Their brighter lamps will light the roadway for great distances where traffic moves at high speeds. In slower speed areas, a vehicle's headlights can provide the driver with the necessary illumination.

Long Beach Converts to High Pressure Sodium Lamps

A public-private partnership was forged between the City of Long Beach and City Light & Power, Inc. (CLP) to provide a streetlighting conversion and management package for the City. Long Beach converted its 32,000 predominately low pressure sodium (LPS) lighting systems on series circuitry to a high pressure sodium (HPS) system on multiple circuitry. The City found that it would be cost effective to convert to a multiple circuitry system because of Southern California Edison's energy tariff structure.

The $18 million conversion program was completed in 1998. The City now pays more in energy costs due to the less energy-efficient HPS lamp; however by converting to multiple circuitry, the City receives $900,000 in energy tariff savings annually from Edison.

Long Beach converted to the HPS lamps primarily due to resident and law enforcement complaints about the LPS lamps. Residents reacted against the dull, unfavorable glow on their surroundings that came from the lamps' orangish-yellow light. Law enforcement officials rejected the LPS streetlighting systems because of safety concerns deriving from the inability to distinguish the true colors of objects under LPS lamps. Since the streetlight conversion, the City has received only a few complaints about the lamps being too bright.

For more information on Long Beach's conversion and management program, call Albert Lebouton, (562) 570-6216.

Successful Uses of Induction Lamps Nationwide

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Places in Use

- The Dalles, OR
- Liberty Science Center, NJ
- Perris, CA
- Philadelphia, PA
- Sacramento, CA
- San Diego, CA
- Tacoma, WA

The following case studies illustrate how the use of induction lighting can affect energy efficiency. In one case, lower wattage induction lamps replaced high pressure sodium (HPS) lamps in the same fixtures for improved efficiency. In the other case, more fixtures were required and, therefore, efficiency was reduced.

San Diego, California

The City of San Diego retrofitted 179 five-globe fixtures in the Gaslamp Quarter, a 16 block National Historic District, in order to create a more pleasing and inviting night-time environment. Philips QL 55W induction lamps replaced 70W HPS lamps that were previously used in the fixtures. Utilizing 895 lamps, the Quarter qualifies as the largest installation of Philips QL induction lamps in the United States.

Maintenance and energy savings of $12,700 are expected each year from the retrofit. The Engineering Department of the City of San Diego estimates that to equal the life of the QL system, four relampings of the high pressure sodium system would be required. Compared to the HPS system, the City will save $43,000 in maintenance costs over the 20 year life of the QL system. The City found that the QL induction lamp is brighter than a HPS lamp of the same wattage. Energy savings result from the City utilizing a lower wattage induction lamp.

The QL induction lamp system has been very favorably received. The Gaslamp Quarter, a very busy pedestrian area for walking, shopping, dining and attending outdoor events, benefits from the full-spectrum white light of the QL induction lamp. Jim Toci, Electrical Engineer for the City of San Diego, states, "The area looks brighter because of the whiter color. QL flatters the colors of people's faces, clothing, and cars, making them look completely natural."

For more information, call Jim Toci, ✆(619) 527-8087.

The Dalles, Oregon

The City of The Dalles approved the first major project in the United States to use the Philips QL induction streetlighting system. Philips QL 85W induction lamps replaced 200W HPS lamps on a 4-1/2 block area of the City's downtown district. Desiring to decrease the City's maintenance costs and liven up the downtown, the new induction lamps were chosen for their long life and their full-spectrum white light. The new system, which is comprised of 48 poles (36 more than the system it replaces) includes a bracket system to hang banners. The new, more pedestrian-scale poles are 13 feet shorter than the old system's 27-foot poles.

The induction system is less energy efficient than the HPS system it replaced, according to Brian Winters of the Northern Wasco Public Utility District, which maintains the streetlights. The smaller wattage QL induction lamp does not have the same lumen output as the HPS lamp – thus the need for more lamps. Instead of supplying only the original 12 lamps, energy must be produced to light 48 lamps in the same area.

Community members have voiced their support for the new, brighter and whiter look of the downtown area. Since the City has received no challenges from the community, it is ready to move forward with its plan to expand the project to 21 blocks in the downtown district even though the new system utilizes more energy.

For more information, call Dan Durow, Community Development Director, ✆(541) 296-5481 or e-mail ddurow @clicknc.com.

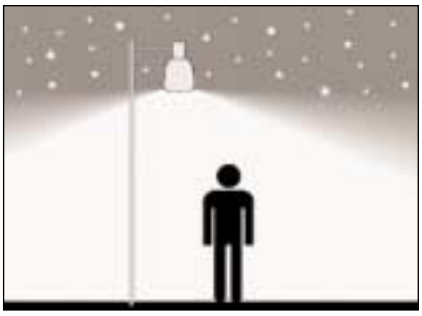
A Quick Comparison of Induction Lamps

	System Wattage	Lumen Output	Lumens per Watt	Min. Starting Temperature
Philips QL55	57	3,500	61	- 4°F (-20°C)
Philips QL85	87	6,000	69	- 4°F (-20°C)
Philips QL165	167	12,000	72	- 4°F (-20°C)
Icetron 100/QT 100	107	8,000	75	-40°F (-40°C)
Icetron 100/QT 150	157	11,000	70	-40°F (-40°C)
Icetron 150/QT 150	157	12,000	76	-40°F (-40°C)

Fixtures and Posts Shed Light on the Subject

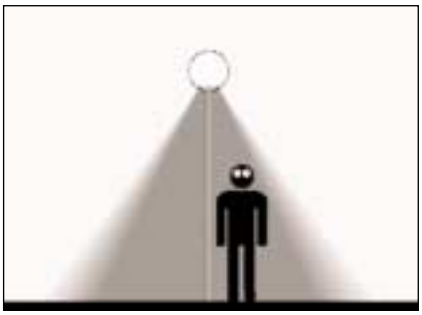
Both lamp and light fixture must be energy-efficient to maximize energy savings. A light fixture's efficiency comes from its ability to direct the light where it is intended. The lamp's height, the distance between poles, and the luminaire's cutoff angle are all important in outdoor lighting design. Luminaire lens material also has a strong effect. Polycarbonates can yellow due to solar and ultraviolet (UV) exposure, thus reducing the system's effectiveness.

Most experts agree that the most efficient streetlight is a full cutoff fixture. A fixture qualifies as full cutoff when it does not allow more than 0.1% of emitted light to illuminate the night sky above a horizontal plane through the fixture and allows no more than 4% of the light to fall in the glare zone range between the horizontal plane and 15 degrees below it.



❶ Full Cutoff Fixture

❷ Semi Cutoff Fixture



❸ Non-Cutoff Fixture

images by International Dark Sky Assn.

Benefits of Full Cutoff

- ➢ More cost-efficient.
- ➢ Directs light down and to the sides as needed; light control.
- ➢ Reduces glare; more even illumination.
- ➢ Reduces light trespass onto neighboring properties.
- ➢ Helps preserve dark night sky.

Davis' "Dark Sky Ordinance" (left) and Sacramento's long-standing commitment to energy-efficient streetlighting (p. 7) illustrate two cities' efforts to find optimal combinations of optics, poles and fixtures.

Davis Preserves Dark Skies

The City of Davis unanimously approved a dark sky ordinance in 1998 to curb light pollution – where artificial light prevents full enjoyment of the night sky. Davis' ordinance creates standards for outdoor lighting which minimize light pollution, glare and light trespass caused by inappropriate or misaligned light fixtures. Not only do such light fixtures intrude on the night sky as a natural resource, they also reduce the street light's energy efficiency by wasting energy to illuminate unnecessary areas.

The Davis ordinance states that all outdoor light fixtures installed after the ordinance's effective date and maintained on private property used for commercial, industrial or multi-family purposes will be fully shielded fixtures that control light output to keep the light in the intended area. All lights and light fixtures that need to be replaced at the end of their life cycles are also required to follow the new standards.

Exceptions can be made for areas where fully shielded light would decrease lighting levels to below minimum Illuminating Engineering Society of North America (IES) illumination levels, negatively impact the aesthetic quality of the area, or for City-approved temporary lighting such as holiday decorations or sporting events.

Davis is planning a gradual retrofit of the City's existing poorly shielded light fixtures. Retrofitting these fixtures will cost an estimated $25,000. The City will also spend $5,000 to produce and disseminate an educational brochure on light pollution for residents.

The City received no complaints from developers who would be responsible for following the new guidelines. Davis' residents will benefit from the new ordinance as it will improve night-time public safety and security by reducing glare and shining the light where it belongs on the ground, while making stargazing possible.

For a copy, call the City Clerk, ✆(530) 757-5602. For more information on light pollution, call the International Dark Sky Association, ✆(520) 293-3198, or visit www.darksky.org.

New Lights Become A Fixture in Sacramento

The City of Sacramento has been active in the area of energy-efficient street lighting since 1971. At that time, high pressure sodium (HPS) became the city standard for new lighting installations for both safety and post-top residential lighting light sources. The City phased out the existing 250-watt and 400-watt mercury vapor luminaires in exchange for 200-watt HPS luminaires.

In 1992, the City replaced all 6,000 of the existing 175-watt mercury vapor post-top residential luminaires with 100-watt HPS luminaires. During the testing process of post-top luminaires from various manufacturers, the City found a low loss ballast that saved approximately 8 watts per luminaire more in energy. An additional $15,000 per year in energy savings was realized as a result. Project funding came from a California Energy Commission loan, with the energy savings repaying the loan.

Sharp cut-off lenses were initially used during installation of the new 200-watt HPS roadway luminaires. But the sharp cut-off lenses created a problem with the public. Because the light could not be seen from the side by many residents, many properly operating lights were reported as burnt out. The City now has new roadway luminaires that use a sharp cut-off lens but with internal optics that allow a more even distribution of light. The "throw" of the light is equal to or surpasses conventional drop-center lenses. Thomas and Betts "Durastar" cobra luminaires were installed in 1995. Their light pattern and distribution is excellent, and because they are so efficient, they require fewer luminaires per block.

In June 1999, the City installed a 200-watt HPS, Gardco "Gullwing" luminaire during the remodeling of an intersection. This luminaire, which is a sharp cut-off type with state-of-the-art internal optics, replaces the cobra luminaire and 12-foot mast arm. This test unit gives excellent light distribution, equal to or surpassing a conventional cobra and mast arm combination. It also does not cause the confusion of whether or not the luminaire is lit.

The Midtown neighborhood project, completed in December 1998, utilized conventional 100-watt HPS lamps and ballasts, but in a joint venture with "LexaLite," the newest technology prismatic acorn lenses were mated to antique street lamp poles and luminaires. This combination provided the antique look with the ability to fully utilize the light output through the acorn lenses. This project was driven by residents and funded by California Block Development Grant monies. In addition to the use of the new technology lenses, the City in partnership with the Sacramento Utility Municipal District installed four Sylvania "Icetron" 100 fluorescent roadway luminaires in one test block. This light source has been well received and will be considered for future developments.

Most recently, the City is examining whether to restore or replace approximately 2,000 deteriorating antique streetlights in some of its older neighborhoods. Public input has been mixed, but a consensus has been reached to use the antique design pole. Still unresolved is whether to replace the poles or refurbish the existing antique poles.

IES Standards – Recommended Light Levels

Site	Average Foot-candles
Collector road (commercial)	0.8 - 1
Local road (residential)	0.3 - 0.4
Commercial parking lot	1.1
Building entry (active use)	5.0

The City is currently obtaining information and pricing for the restoration process. The light source is another issue being researched. The public favors a white light source. The mercury vapor lamp will not be considered due to environmental issues and low efficiency. Metal halide has been mentioned; however, its service life is less than half that of the HPS source.

The alternative light source the City is testing is the Sylvania "Icetron" and the Phillips "QL-85" induction lamps. The main problem with these sources is the difficulty in retrofitting this lamp and driver combination to the existing luminaire if the City chooses to restore the antique poles. The City is currently in discussion with the Sylvania and Phillips engineers about this issue.

The City – in partnership with the Sacramento Municipal Utility District, Lawrence Berkeley Labs, and L.E.D. Effects – is working to develop a light-emitting-diode replacement for the high intensity discharge lamp technology now in use. This light source will be full-spectrum, energy-efficient, environmentally friendly and extremely long-lived.

For more information, call Wesley Hiratsuka, Lighting and Signal Supervisor, City of Sacramento, (916) 433-6313.

Downward Lamps Help Tucson Sky Light Up

City Converts to Sodium Lamps

The City of Tucson's street-lighting strategy is designed around its full cut-off lighting ordinance, which requires that light be directed downwards. The ordinance aims to install a more cost-effective lighting system which reduces glare – ultimately preserving the spectacular Arizona desert skies as a natural resource for residents.

Light Levels of Familiar Times

Time	Avg. maintained foot-candles
Full moonlight	.01 - 0.1
Pre-dawn	.01 - 1.0
Windowed room, cloudy day	6.0 - 8.0
Bright sunlight on the beach	30,000

Outdated, inefficient mercury vapor lamps were replaced with full cut-off, high-pressure sodium (HPS) lighting systems for larger, faster-moving roads and full cut-off, low-pressure sodium (LPS) lighting for residential streets. The change provided significant cost savings because HPS and LPS systems are more energy-efficient than mercury vapor lighting systems.

Even though the City's lighting ordinance states a preference for LPS systems, the City uses a mixed lighting design plan. The City decided to utilize the less harsh and glary, more energy-efficient LPS lamps on residential streets where traffic moves slow enough to offset potential color rendering difficulties. On major arterial roads which carry more traffic at higher speeds, the City found the color rendering and illumination properties of the HPS lamps better suited.

Police and residents initially opposed the conversion. The police department was concerned with the difficulty of identifying colors and suspects under the lamps' yellowish-orange light. And residents were accustomed to their old lighting system and wary of change. Since the conversion, however, both the police department and residents favor the new lighting.

For more information on the City of Tucson's lighting design plan, call Lighting Engineer Dick Guthrie, ✎(520) 791-3154.

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