

Municipal Policy Options Guide for Advanced Outdoor Lighting

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Prepared by:
Canadian Urban Institute
555 Richmond St. W.,
Suite 402, PO Box 612
Toronto, ON M5V 3B1
Canada
P 416-365-0816
F 416-365-0650
cui@canurb.com
http://www.canurb.org

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Canadian URBAN Institute

Research Team:

Canadian Urban Institute

Brent Gilmour, MCIP RPP, Vice President, Urban Solutions
Simon Geraghty, Senior Engineering Researcher
Katherine Morton, Senior Economic Research Planner
Christine Carr, Planner

With contributions from:

John Warren, P.Eng. Senior Associate, Senior Engineer, Urban Solutions
Aurelie Petitjean, Engineering Research Associate
Philippa Campsie, Hammersmith Communications

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Preface

The Toronto Atmospheric Fund (TAF) LightSavers program was launched in 2008 with support from Natural Resources Canada (NRCan) and the Ontario Power Authority (OPA). The program helps municipalities and partners in the Greater Toronto Area and across Canada advance the use of Light Emitting Diodes (LEDs) and the implementation of adaptive lighting techniques for outdoor lighting. Outdoor lighting represents a tangible and significant opportunity for energy savings and greenhouse gas (GHG) reductions for Canadian municipalities.

The Canadian Urban Institute (CUI) was retained by TAF to develop a policy guide for municipal practitioners and decision-makers to aid with the acceleration and uptake of LEDs and adaptive lighting technology for advanced outdoor lighting.

Executive Summary

Street lights and traffic lights represent up to 13 percent of the electricity consumption in a municipality. Advanced lighting technologies, including replacing conventional light sources with LEDs (light emitting diodes) and using timers or motion sensors to ensure that lights are illuminated only when needed, offer a way to reduce energy use. Since energy conservation means lower costs and lower greenhouse gas emissions, these technologies offer both economic and environmental benefits to municipalities.

At the same time, uptake of these energy-efficient technologies can be slow because of high upfront costs for installation, standards and codes that preclude the use of the new technologies, or a belief that the technologies may reduce safety in public spaces.

These technologies are new, and are continuing to evolve, yet the case studies presented in this report show that they can help municipalities save money and achieve other benefits, such as improved safety and the reduction of night-time "light pollution" (a problem that affects the health of humans and wildlife).

The report looks at the use of advanced lighting technologies in Ann Arbor, Michigan; Los Angeles, California; Toronto and Ottawa, Ontario; and Vancouver, British Columbia. All these cities have started to use LEDs in municipal streetlights and traffic lights and three have introduced adaptive technologies for municipal lighting. The cities differ, however, in the extent to which they have used partnerships, incentives, and regulations to promote the use of advanced lighting technologies by the private sector.

The case studies also shed light on some of the common challenges in introducing advanced lighting technologies. These include:

- gaining public acceptance for LEDs in public spaces or the use of adaptive technologies;
- keeping up with changes in this rapidly evolving field;
- covering the initial cost of installing the technologies;
- ensuring consistency with existing building and lighting codes and standards;
- capturing the energy and cost savings in conjunction with local utilities (most of which do not meter streetlights and recover costs through a flat rate).

The report concludes with 14 actions that municipalities can take to promote the use of energy-saving lighting technologies, from using pilot projects to demonstrate the benefits and win public acceptance to developing comprehensive lighting policies that promote greater uptake of the technologies.

1 Introduction

New technologies, such as Light Emitting Diodes (LEDs) and adaptive lighting technology (using dimming controls and light and motion sensors), represent an important opportunity for municipalities to advance energy and greenhouse gas (GHG) reduction. Since street lighting and the operation of traffic control signals can represent up to 13 percent of the total electricity consumption of a municipal corporation, these technologies have the potential to save significant amounts of energy.[1]

LED technology and adaptive lighting controls are proven, energy-efficient options for use in outdoor applications such as parking facilities, area lighting, and street lighting. LEDs in combination with adaptive monitoring and control technologies can achieve as much as 70 percent in energy savings, and reduce light pollution through better control of light direction and dimming during non-peak periods.[2] LED technology can now meet or exceed international standards for illumination levels, while reducing the use of electricity.

Although these benefits of LEDs and adaptive lighting technologies are proven, the application of advanced outdoor lighting has yet to realize its potential in municipalities across Canada.

Municipal Policy Options for Advanced Outdoor Lighting was prepared for municipal decision-makers and staff to support the implementation of advanced outdoor lighting policies and the use of LEDs and adaptive lighting technologies. The guide is intended to be used by municipalities in updating their street lighting infrastructure or in developing an outdoor lighting policy.

The guide:

- reviews the importance of outdoor lighting and defines LEDs and adaptive lighting;
- identifies the benefits of developing an outdoor lighting policy;
- provides case studies of best practices from across North America;
- includes examples of advanced outdoor lighting policies;
- provides a detailed glossary of terminology and technical standards related to advanced outdoor lighting.

Approach to Developing the Guide

In creating this guide, the authors interviewed staff in a number of Canadian and U.S. municipalities, particularly those that had successfully implemented LED or adaptive lighting technologies, and/or created or updated a lighting policy that supports advanced outdoor lighting. The interviews focused on what had led to the development of an advanced outdoor lighting policy or program, including the drivers, champions, cost, opportunities, and obstacles.

[1] Local Authority Services (2008) *Ontario's Guiding Lights Street Lighting Addressing Energy Efficiency & the Environment.*
[2] Interview with Ed Ebrahimian, City of Los Angeles, Director of the Bureau of Street Lighting.

2 What Is Outdoor Lighting and Why Is It Important?

"Proper outdoor lighting enhances the safety of citizens and ensures the security of property. Outdoor lighting is used to illuminate roadways, parking lots, yards, sidewalks, public meeting areas, work sites, homes, and building exteriors. Good lighting increases the visibility of hazards, improves the safety of citizens, and provides a sense of security in the community. Visibility can be compromised by light pollution, but this can be mitigated by responsible lighting practices."

– Royal Astronomical Society of Canada

Most outdoor lighting is used to ensure visibility in outdoor areas used by pedestrians (walkways), vehicles (roadways) or both pedestrians and vehicles (parking lots). Lighting in these areas helps users avoid hazards and locate vehicles. This section reviews the role of outdoor lighting and explains the concept of advanced outdoor lighting.

Proper outdoor lighting design and policy address matters relating to visibility and security, road safety, energy costs, and ways of minimizing the careless or inappropriate use of outdoor lighting and associated negative impacts on human health.

Safety, Security, and Community Vitality

The general principle of outdoor lighting is to enhance visibility at night. For vehicle drivers, the lighting provided by headlights alone is adequate only at low speeds. At higher speeds, a driver must be able to respond quickly, accurately, and comfortably to road hazards, including pedestrians, cyclists, animals, or debris. For pedestrians, lighting of sidewalks provides for increased visibility and a sense of safety.

Good visibility makes an outdoor space more usable and accessible, attracting a greater number of night-time visitors. This higher patronage in turn contributes to the safety of an outdoor space. Moreover, well-designed outdoor lighting can enhance the quality of the public realm and increase residents' and visitors' enjoyment of architecture and public spaces. In this way, high-quality outdoor lighting design has a critical role in promoting safety and improving the quality of public space for a community.

Environmental and Economic Costs

The amount of energy consumed for outdoor lighting is directly related to the amount of luminaires (lighting fixtures), the luminaire type, the luminaire's efficiency and light distribution, as well as the lighting control strategy. The cost of operating an outdoor lighting system depends on several factors, including operation, maintenance, annual energy costs, and the upfront costs of equipment and installation.

Maximizing the energy and economic performance of outdoor lighting involves carefully balancing illumination needs with available energy-efficient equipment. For instance, reducing the number of hours of outdoor lighting can lower energy usage and costs, because not all outdoor lighting needs to be on at full output all night long. Achieving reductions may involve the use of adaptive lighting techniques (motion sensors, photo sensors, timed devices) and of more efficient lighting, such as LEDs. Good lighting can also reduce costs related to vandalism, accidents, and associated liability.

Light Pollution

Careless and excessive use of lighting is often referred to as *light pollution*. Light pollution can compromise safety, disturb or confuse wildlife, create disturbances in rhythms of day and night that are vital to natural systems, and affect the appearance of a community. Light pollution includes three distinct phenomena: *sky glow*, which is a brightening of the sky that impedes a view of the stars; *light trespass*, which occurs when light spills into an area where it is not wanted or needed; and *glare*, a visual sensation caused by excessive and uncontrolled brightness. The environmental, economic, and social impacts of light pollution can be minimized through appropriate lighting design, luminaire selection, and lighting controls.

Human Health

Outdoor lighting that shines into homes, businesses, and other places of work can affect human health. Improperly directed light can affect the body's biochemistry repair mechanisms, including its resistance to cancer.[3] Our bodies require sleep for repair from daily activity. Light trespass from street lighting can upset the body's natural rhythms. As well, the incorrect use of lighting, such as street lighting that is excessively bright and unshielded, can make it difficult for senior citizens to see. This is particularly true for street lighting that uses white light. White light is composed of a broad spectrum of colours and white light that is rich in blue wavelengths is known to reduce visibility in areas of low illumination.[4]

Conventional outdoor lighting technologies (high pressure sodium and metal halide) rely on mercury in the bulbs which can be a threat to human health even in very small doses if not disposed of properly. LED fixtures typically do not contain any mercury, but can contain other types of hazards metals at very low levels. All forms of energy-efficient lighting (LEDs, compact fluorescents, high-pressure sodium lights, etc.) require safe handling and should be disposed of as hazardous waste.[5]

Lighting policies can help ensure the correct installation of outdoor lighting, including commercial signage. Policies can also raise awareness about potential human health, safety, and environmental issues among other professionals who influence outdoor lighting choices, such as planners.

2.1 What is Advanced Outdoor Lighting?

Advanced outdoor lighting involves the use of new energy-efficient lighting technologies, such as LEDs and adaptive lighting techniques, in outdoor environments, including parking garages.

2.2 What are LEDs and Adaptive Lighting Technologies?

LEDs are a technology for turning electricity into light. Adaptive lighting technologies allow for the automated dimming or extinguishing of lights when they are not needed. LEDs and adaptive lighting technologies can be used to increase energy efficiency, while reducing energy costs and GHG emissions.

Light Emitting Diodes (LEDs)

LEDs are solid-state semiconductor devices that convert electrical energy into visible light. LEDs have long been used for decorative

[3] Dick, R. (2010). *Smarter Ways to Think About Artificial Outdoor Lighting*. *Ontario Planning Journal* 25(6): 8-9.
[4] Ibid.

[5] Seong-Rin Lim et al. (2011). Potential Environmental Impacts of Light-Emitting Diodes (LEDs): Metallic Resources, Toxicity, and Hazardous Waste Classification. *Environmental Science Technology*, 45 (1): 320–327.

applications (such as Christmas lights) and have now become the standard for traffic signals and emergency exit signs.

LEDs have recently been developed for street and area lighting applications and can reduce energy consumption in these applications. LED luminaires use about half the energy of conventional fixtures, which means both cost and GHG savings.[6] Although they offer many benefits and interest in them is increasing, LEDs are still a relatively new technology and have not yet become common practice for outdoor lighting.

The advantages of LED lighting include:

- long-term energy and GHG savings;
- reduced energy costs;
- reduced maintenance costs;
- capacity for instant illumination;
- dimming ability using lighting control strategies;
- longer product lifetimes, resulting in reduced replacement costs;
- a quality of light that better approximates sunlight and can contribute to better colour and contrast perception and enchanced crime prevention;
- reduced light pollution, because light can be directed where it is needed;
- reduced use of environmentally hazardous chemicals, such as mercury, which requires special handling and disposal.

Some disadvantages of LED streetlights include:

- initial high capital costs (because the product is relatively new in the marketplace);
- lack of long-term testing and application experience for municipal needs, given the newness of the technology;
- difficulties for end users in keeping pace with product changes or sourcing replacement parts, given the rapid development of LED technology;
- wide variation in production availability, options, and quality, because the LED manufacturing industry is still developing.

Adaptive Lighting Technologies

Adaptive lighting technologies are systems that vary lighting levels based on activity levels. By dimming lights during periods of low traffic use or pedestrian activity, a municipality can reduce energy costs and GHG emissions, while reducing light pollution.

Most adaptive lighting systems use photo sensors to turn lights on when ambient (natural light levels) light levels fall below a certain level of desired lighting. Newer adaptive lighting technologies are now providing additional benefits through control strategies that allow for remote monitoring of a luminaire fixture. These include:

- controlling the performance of individual fixtures, groups of street lights, or an entire network from a centralized location;
- setting light level transition times for a lamp on a periodic basis (e.g., dawn and dusk);
- adjusting light output levels to reduce energy consumption during off-peak hours;
- notifying controllers of outages and other problems for improved maintenance;
- performing accurate energy use calculations.

[6] Interview with Ed Ebrahimian, City of Los Angeles, Director of the Bureau of Street Lighting.

Like LEDs, adaptive lighting technologies are relatively new for outdoor lighting applications. Future benefits of adaptive lighting technologies could include:

- integration with Smart Grid infrastructures;
- integration with existing asset management processes, such as geographic information system (GIS) databases;
- movement of data from other sources or technologies using wireless networks;
- optimization of street lighting for varying road, weather, and emergency conditions;
- prioritization of repairs in high-accident areas, intersections, mid-street crosswalks.

Adaptive techniques can be used alone or in conjunction with LED fixtures to offer increased energy efficiency.

3 What Is an Outdoor Lighting Policy?

Most lighting policy is designed to enhance safety and security to people and property, control aesthetics in a defined space, and deliver lighting economically in terms of equipment, installation, operation, and maintenance, while minimizing environmental impact. This section reviews the traditional focus of outdoor lighting policy approaches and sets out a framework for the use of advanced outdoor lighting applications through policy and supportive actions.

3.1 Outdoor Lighting Standards and Codes

The primary approach for regulating outdoor lighting is through the use of standards and codes.

Across Canada, municipalities and provincial regulating agencies generally refer to the industry standards established by the Illuminating Engineering Society of North America (IESNA) and the Transportation Association of Canada (TAC) when developing policy and codes for outdoor lighting.[7] An overview of the standards, codes and policies relevant in Canada for outdoor lighting is outlined in *Appendix A - Annotated Glossary and General Information* and expanded in *Appendix B - Existing Municipal Standards for Outdoor Lighting*.

Outdoor lighting is not a regulated requirement for municipalities or utilities in Ontario. Although consensus exists about the importance of lighting, there is little consensus among lighting national and international coordinating bodies about where and when to apply outdoor lighting in public areas.

[7] The International Commission on Illumination (CIE) defines a recommended design practice for Europe and many areas outside of North America. The TAC documents are derived from IESNA research and publications.

The recommended standards set out by the IESNA give only broad direction to lighting designers and code evaluators about how to evaluate the need for outdoor lighting. Most of the standards developed by IESNA specify minimum averages for illumination and are not easily transferred into enforceable codes. Currently, IESNA does not provide detailed guidance on the use of alternative lighting and control technologies, such as LEDs and adaptive lighting.

The use and application of outdoor lighting for built structures and private areas are subject to enforceable building codes and municipal codes. These codes regulate the location, use, illumination levels, and other factors related to outdoor lighting.

Building codes are the responsibility of provinces and territories. National direction on uniform standards and codes is provided by the National Research Council (NRC) and the Commission on Building and Fire Codes (CCBFC). These codes represent the core requirements for most provincial and territory building standards. Most provincial building codes in Canada give some direction on interior and external lighting requirements for built structures.

Municipal codes set property standards and are the primary tool applied to control outdoor lighting in private spaces, such as parking lots, walkways, stairs, porches, verandas, loading docks, and ramps, and for public spaces, including sidewalks, roadways, underpasses, and rights of way.

The Drawbacks of Current Standards and Codes

Most outdoor lighting codes focus on enhancing visibility at night. These codes provide guidance only on acceptable minimum or average illumination levels and not on the type of technology to be used. As well, most lighting codes have minimum regard for

energy efficiency and potential energy cost savings. Lighting designers and code evaluators must rely on their professional knowledge and training to evaluate the type of lighting and control technology that should be used.

The minimal direction provided by outdoor lighting codes can result in a wide variety of interpretations and inconsistencies. Important municipal objectives, such as reducing energy, GHG emissions, and light pollution are not addressed in the codes.

Lighting codes and standards do not always encourage the application and use of innovative and new technologies. Codes and standards for lighting are also not intended to facilitate cross-departmental coordination to support advanced outdoor lighting, encourage the use of demonstration projects, or set out approaches for collaborating with local utilities to fund advanced outdoor lighting initiatives. These actions are best guided by the development of advanced outdoor lighting policy and supportive actions.

Basic Elements of an Outdoor Lighting Policy

Lighting policies can be divided between those that provide guidance for the control of lighting for public rights-of ways such as roads, highways, sidewalks, and parking areas and those that deal with lighting for private lands or privately owned roads, lanes, and parking structures.

At a minimum, municipal outdoor lighting policies should clarify where outdoor lighting is required and specify the required lighting design requirements for various types of streets, parking areas, and pedestrian areas.

Municipal outdoor lighting policies may also include design standards for minimizing light pollution; design standards for integrating adaptive controls; specifications for minimum levels of energy efficiency for new outdoor lighting; specifications for acceptable ranges for colour rendering; standards for variations in lighting levels; and specifications for which technologies can be used.

Municipal outdoor lighting policies tend to be distributed across separate policy documents, by-laws, or zoning by-laws; however, awareness and compliance can be enhanced through a single comprehensive policy. An example of a consolidated Outdoor Lighting policy is provided in Appendix D for the City of Ottawa. The policy addresses a range of needs as they relate to managing public right-of-way lighting.

3.2 Benefit of Outdoor Lighting Policies and Supportive Actions for LEDs and Adaptive Lighting

The development of advanced outdoor lighting policies can contribute to overcoming market barriers, which include inconsistencies in design, public perceptions, capital costs, unfamiliarity with the new technologies, and policy issues.

Creating Lighting Design Consistency

Given the lack of consistency and consensus about lighting standards, municipalities are often on their own in making decisions on issues such as which areas to light, how much light is required (and at what times), and which lighting technologies should be used. A survey of outdoor lighting policies in Canadian municipalities undertaken by the Union of Nova Scotia Municipalities found that practices for developing standards

varied from province to province and from municipality to municipality.[8]

A clear and comprehensive lighting policy can ensure consistency in lighting design, streamline maintenance and purchasing decisions, and help designers and asset managers better determine light location, fixture type, wattage, illumination levels, and uniformity. A policy can also contribute to a better blending of new development lighting needs with existing neighbourhood standards.

Addressing Public Perceptions

Public perception of outdoor lighting is important. Outdoor lighting needs to balance concerns about safety, crime prevention, colour, aesthetics, appropriate light levels, and light pollution. The use of LEDs and adaptive lighting techniques can change the perception about how lighting is operating in a community. For instance, adaptive lighting techniques that dim lights during off-peak hours can lead to concerns about personal and vehicular safety. Communicating the benefits of LED and adaptive lighting are important components of any policy on outdoor lighting.

Addressing Capital Cost Barriers

Most LEDs used in street and area lighting have higher up-front capital costs, but lower lifecycle costs in terms of maintenance and operation. One of the challenges to using LEDs for outdoor lighting is adequately capturing the energy cost savings in municipal budgets. For example, most street lights are unmetered and utilities commonly charge a flat rate per fixture. Since most utilities have not created new rates for either LED fixtures or adaptive control systems, realizing the cost savings may require negotiation of new rates with local utilities. This is an acknowledged industry-wide barrier to encouraging the market uptake of the technology by utilities and municipalities.

Adequately capturing cost savings can become a challenge when a municipality does not own a utility and is responsible for street lights. An outdoor lighting policy can contribute to developing cost-sharing agreements between a municipality and a local utility and address issues about the ownership of light fixtures, costs of implementation, testing and maintenance, and who benefits from energy cost savings.

Encouraging Uptake of New Technologies

LEDs and adaptive lighting applications for outdoor lighting are new and unfamiliar to many lighting designers and code evaluators. Because this technology is rapidly evolving, there is limited information available on industry standards, expected operating and installation costs, and the performance of different lighting fixtures. To address these limitations, municipalities are undertaking pilot studies to evaluate where and when to use LEDs and adaptive lighting technology. Lighting policies can help address lighting industry knowledge gaps and facilitate the wider uptake and application of innovative lighting technologies.

Clarifying Legal Liabilities and Policy Conflicts

Although outdoor street lighting is not a legislated requirement for municipalities in Ontario, there is an expectation that municipalities will provide illumination for safety reasons. It is also widely recognized within the lighting community that municipalities should use the latest standards to minimize any potential liability. The development of an outdoor lighting policy can contribute to minimizing the potential liabilities for a

[8] DMD and Associates Ltd (2009) *Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities,* prepared for the Union of Nova Scotia Municipalities (UNSM).

community, while removing discrepancies between different codes. For instance, the Ontario provincial building code encourages the use of energy-efficient equipment, such as motion-controlled lights, as part of the construction process. However, a municipal property code may establish a standard that inadvertently limits or prohibits the use of adaptive lighting.

3.3 Applying Outdoor Lighting Policies and Supportive Actions for LEDs and Adaptive Lighting

From the review of leading municipal practices in the U.S and Canada for advanced outdoor lighting, a common framework was identified for developing advanced outdoor lighting policies and supportive actions. Three specific categories of policies and supportive actions were identified: (1) actions a municipality can take as a corporation (leading by example), (2) actions a municipality could encourage others to take (partnerships and incentives), and (3) actions a municipality could compel others to take (regulation).

Activities a Municipality Can Take as a Corporation (Leading By Example)

Municipalities are often called upon to demonstrate leadership to raise interest and awareness to help advance change. The starting point for advancing the uptake and application of LEDs and adaptive lighting technologies generally begins with a pilot test or demonstration project by a municipality. In Ann Arbor, LED manufacturers were encouraged for over five years to showcase and demonstrate leading products on municipal properties. In Ottawa and other Ontario communities, demonstration projects used LEDs and adaptive lighting techniques to draw attention to their potential for energy savings and improved safety on highways and roadways.

In other cases, education and awareness were considered the most effective tools in galvanizing support among municipal departments and local communities. In Los Angeles, community outreach in the form of workshops and building awareness about the benefit of LEDs are credited with contributing to enhanced public support and acceptance of advanced outdoor lighting.

Actions a Municipality Can Encourage Others to Take (Partnerships and Incentives)

Municipalities are often most influential and effective when they collaborate with other organizations in the community. All the municipalities reviewed for the guide worked with their local electricity service provider to explore the application of new lighting technologies, as well as financial mechanisms to address higher capital costs for technologies and to recover energy cost savings.

In Los Angeles, Vancouver, and Ottawa, pricing schemes or tariffs were introduced to account for the expected energy savings from using LEDs and adaptive lighting technologies. In Ann Arbor, working with the Local Economic Development Corporation made it possible to secure additional grants and loans for investing in street lighting infrastructure as part of a downtown revitalization project.

Actions a Municipality Can Compel Others to Take (Regulations)

Municipalities have regulatory authority and can use it to advance a range of goals, particularly those relating to maintenance, uniformity, and safety. The regulatory tool usually takes the form of property standards, which can be used to encourage the use of more energy-efficient lighting. This approach is being applied primarily in the United States.

Land use regulation tools can be used to direct the use of specific technologies. For instance, municipalities in both the United States and Canada can use conditions for subdivision approvals and site-specific approvals to encourage the development and building community to use advanced outdoor lighting applications, including LEDs and adaptive lighting technologies.

4 Case Studies of Municipal Advanced Outdoor Lighting Polices and Supportive Actions for LEDs and Adaptive Lighting

Municipalities across Canada are developing policies and supportive actions to advance the use and application of LEDs and adaptive lighting technologies. These initiatives are creating broader awareness of the environmental and economic benefits of advanced outdoor lighting technologies and helping harmonize outdoor lighting practices and regulations.

The five case studies review the experiences of municipalities in the United States and Canada that have implemented advanced outdoor lighting initiatives for LED and adaptive lighting applications through demonstration projects, partnerships and incentive programs, and regulatory activities.

Case Studies						
	LEDs			Adaptive Lighting		
	Leading By Example	Partnerships and Incentives	Regulation	Leading By Example	Partnerships and Incentives	Regulation
City of Ann Arbor, MI	●	●	●	●		
City of Los Angeles, CA	●		●			
City of Toronto, ON	●			●		●
City of Ottawa, ON	●			●		●
City of Vancouver, BC	●				●	

4.1 LED Lighting Applications

City of Ann Arbor, MI

Overview

Ann Arbor has used innovative technologies, such as LEDs and adaptive lighting, to reduce public lighting costs. After a successful pilot of LEDs for the City's "globe" streetlights, the City received a grant from the Downtown Development Authority (DDA) to fund retrofits of over 1,000 downtown lights. The retrofits are expected to save the City $100,000 in annual energy costs and reduce annual GHG emissions by nearly 267 tonnes CO_2e.

The City of Ann Arbor has the goal of replacing all streetlights with energy-efficient LEDs. Full implementation would cut Ann Arbor's public lighting energy use in half and reduce GHG emissions by 2,200 tonnes CO_2e annually. The City has used building and development policies to encourage the uptake of LED.

Context and Drivers

In 2005, the Council of Ann Arbor established a moratorium on new street lighting as part of a fiscal package to keep costs under control. Street lighting was the largest single component of the City's energy budget, which was funded through the general municipal tax base rather than through a directed levy. This funding arrangement meant that the City could not increase rates as costs increased (another example of a rate-funded entity is the municipal water system).

In response, City staff were directed to find ways of reducing public lighting costs. This led the City to test different lighting technologies. After a successful experience replacing incandescent traffic signals with LEDs, the City agreed to partner with the International Council for Local Environmental Initiatives (ICLEI) to investigate LEDs for outdoor public lighting as part of the Great Lakes Climate Policy Project.

To assess LED technologies, the City invited manufacturers to offer their own LED fixtures for installation on public properties. The City evaluated the performance of each of these LEDs. Over a two-year period, the test area for LEDs was expanded from the City Hall parking lot to roads and neighbourhoods. In the most recent two years of testing, the City has experienced significant improvement in the light output and colour rendition for LED fixtures.

As part of the program, Ann Arbor residents and businesses were encouraged to comment on the LED lighting program. To date, the response continues to be overwhelmingly positive. Community members appreciate the cost savings, reductions in "light trespass," and the fact that the LEDs provide similar tones/shades of lighting as those provided by the City's original metal halides. Support is increasing for the wider uptake and adoption of more energy-efficient street lighting.

Lessons Learned

Industry information on LEDs is continuing to develop. At the time of the study, the manufacture of LED street and area lighting fixtures was just beginning on a larger scale and little information was available on the reliability, ease of retrofit, and other product information required for larger-scale municipal applications. As a result, all LED product testing for this project was undertaken by City staff.

Today, new testing standards for LEDs, such as the LM-79, LM-80, and TM-21 standards, make it possible to compare LED

products. Product testing is still a good way to assess retrofit requirement and applicability in a community. The results of testing can be benchmarked against available market information.

Cost-sharing agreements and engaging with local utility early on can capture LED energy and maintenance cost savings. The city of Ann Arbor is currently paying the local utility a technology-based fixed fee that incorporates both the energy and maintenance costs. The City worked with the local utility to develop an appropriate fixed fee for LEDs that accounts for the higher initial capital costs and long-term lower maintenance requirements and electricity consumption.

To benefit from the energy and maintenance cost savings of LEDs, municipalities that are not maintaining streetlights or are unable to directly capture the economic benefits should consider a cost-sharing model prior to launching a city-wide LED outdoor lighting initiative.

Engaging early on with a local utility in developing a mechanism to capture savings from more energy-efficient lighting can result in innovative uses of energy, as well as more effective municipal regulations and acts. In Ann Arbor, the municipality worked with the utility to evaluate the introduction of a new rate class to capture the energy savings associated with LEDs. In the state of Michigan, establishing a rate for outdoor lighting energy costs (which are not metered) requires testing and validation of the installation and operating costs of lighting technology by a utility. Before a new rate can be set, a utility needs to demonstrate to the State that the rate is reasonable. For Ann Arbor, successful discussions with the local utility resulted in the establishment of a new rate that captured the energy cost savings associated with LEDs installed in the community.

High capital costs for LEDs can be addressed with innovative partnerships. After the successful piloting of LED streetlight replacement in the downtown area, the Downtown Development Authority (DDA) – a municipal agency that helps undertake and coordinate downtown renewal projects – gave the City a $630,000 grant to cover the entire retrofit of all downtown lights to LEDs. The retrofit project is expect to save the City $100,000 in annual energy costs for just the downtown area and provide a reasonable payback and long-term energy cost saving opportunity. The DDA grant was structured to ensure that a portion of the savings from the retrofits would be used to fund and pay for future retrofits across the City.

Municipalities can use a variety of financing and partnership models to reduce financial and technical risks for outdoor lighting initiatives. Although few Canadian municipalities have development authorities like the DDA, these authorities often have the capacity to direct dedicated funds to aid with renewal projects for downtowns, waterfronts, employment lands, and other priority areas for revitalization in a municipality.

Municipalities can use traditional tools to encourage the progress and application of emerging technologies such as LEDs. As part of a cost-containment approach, Ann Arbor City Council enacted a moratorium on new street lighting. This meant that City staff had to recover the cost of installing new street lighting by levying a development charge or special assessment on new developments. New developments in Ann Arbor are now expected to cover the cost of installing LEDs.

The capacity for Canadian municipalities to use existing policy tools to recapture servicing costs for new developments and encourage the use and application of a technology varies by province. Generally, municipalities can include the costs of municipal infrastructure costs (roads, sewers, lighting etc.) for new subdivisions. In Canada, municipalities generally do not prescribe a specific technology as part of a special assessment or approvals process, but they do have the regulatory capacity to give greater direction for the use of energy-efficient lighting, especially for new development applications.

More Information

Contact details:
Andrew Brix
Energy Programs Manager
City of Ann Arbor
734-794-6430

Website:
http://www.ledcity.org/lib/resources/Ann%20Arbor%20LED%20Summary.pdf

City of Los Angeles

Overview

The LED Street Lighting Energy Efficiency Program, managed by the Bureau of Street Lighting, involves the replacement of 140,000 of the 209,000 existing street lights in the City with LEDs. This is now the largest LED street light replacement program in North America. The lighting replacement program is intended by to reduce energy by a minimum of 40 percent, decrease carbon emissions, and cut maintenance costs for the City's street lighting system.

Context and Drivers

Two issues helped in the development of the LED Street Lighting Energy Efficiency Program for Los Angeles. The first was the passing of Proposition 218 in California in 1996, which limited municipalities' ability to adjust assessments for municipal services (including lighting), property-related fees, and general-purpose taxes without going to a public ballot for approval. Before this time, a municipality, by a vote of council, could move to raise assessments without going to a ballot. Because it was felt that the public would not support an increase to municipal service fees for street lighting, Proposition 218 effectively led to many restrictions being applied to the City of Los Angeles to finance the operations, maintenance, and servicing of street lighting.

The second issue was the inclusion of Los Angeles among the American cities identified as having high levels of air pollution. The Mayor of Los Angeles challenged City staff to reduce operating costs, while making the City cleaner, greener, and healthier.

Among the initial ideas identified for helping to address air pollution and save money was improving the City's street light inventory. Street lighting in Los Angeles was found to be a high energy user for the community, consuming 168 gigawatt hours of electricity annually and costing the City $15 million a year. Initial modelling of outdoor street light replacement options for Los Angeles allowed the Bureau of Street Lighting to consider the potential for LEDs.

Working in collaboration with the Mayor's Office and the Clinton Climate Change initiative, the Bureau of Street Lighting developed a long-term cost-effective lighting replacement program that focused on LEDs. The LED Street Lighting Energy Efficiency Program began in 2008 with the launch of several pilot projects. The pilot projects allowed local residents to comment on the use of LED technology and provided the Bureau with an opportunity to evaluate different LED technologies. As part of the initial pilot project, the Bureau consulted with various public agencies, including the Los Angeles Police Department (LAPD). LAPD supported the use of LEDs to improve safety and crime prevention through better visibility.

Following the pilot testing phase, the LED Street Lighting Energy Efficiency Program was passed by Council and approved for deployment in 2008. The program is intended to be completed within five years and will cost a total of $57 million. The City replaced 20,000 street light fixtures within the first year of the program and realized an energy saving of 55 percent, exceeding initial expectations. The cost of the program is intended to be paid back in seven years from the savings in energy and maintenance costs. Upon full implementation of the program, the City hopes to realize savings of $10 million annually.

Most of the funding for the program came from a loan from the city-owned utility company, the Los Angeles Department of Water and Power. A memorandum of understanding (MOU) was signed by the Bureau and the utility company that would guarantee that funds would be available for the duration of the program and that the loan would be paid back within seven years. The remaining funding was provided through an energy rebate program run by the utility company and the Bureau's own funds.

Lessons Learned

LEDs and adaptive lighting can provide significant cost savings. The total operating budget for street lighting in the City of Los Angeles is $22 million a year. Approximately $15 million is used to purchase electricity. After converting 20,000 streetlights during the first year of the program, the City started to see energy savings of almost $700,000 a year. These savings now contribute to an annual rebate from the local utility, the Department of Water and Power, to the Bureau.

The City plans to convert 140,000 street lights to LEDs in five years. This conversion program is expected to save the City $10 million a year. This translates into a payback period of seven years for the new LED luminaries that use the existing poles. Municipalities can access affordable loans from utilities and development authorities to make long-term capital investments that have a positive payback. The rate of payback for new advanced lighting technologies is expected to accelerate as the cost of energy continues to rise across North America. This option should be considered when evaluating the use of LEDs and adaptive lighting.

Partner to improve project financing and reduce development risk. A loan and grant provided by the Los Angeles Department of Water and Power was central to ensuring the financial success of the project. Total project costs amounted to $56 million, of which $40 million was a loan from the utility and $16 million was from an energy rebate. Partnerships with local energy providers can help reduce project risk and improve access to financing. When considering financial options for adaptive outdoor lighting, consideration should be given to the rate and level of energy cost savings that can be achieved, as well as avoided maintenance costs.

Local policy tools can be used to encourage advanced outdoor lighting. Policy tools, such as building codes, zoning bylaws, and municipal standards can be used to encourage the uptake of advanced outdoor lighting technologies. In Los Angeles, LEDs for street lighting are now required as part of a new building application or plan of subdivision. Developers and homebuilders submitting applications are expected, as a condition of approval, to include LEDs in street lighting. This requirement was enacted through a zoning ordinance outlining lighting requirements.

This application requirement was acknowledged by the development community as beneficial because of the long-term energy cost savings. Increased market acceptance of LEDs has made them the municipal and industry standard for street lighting installations.

Municipalities need to work with utilities to capture and price energy savings. The first step for municipalities in securing energy cost savings from energy efficiency improvements to outdoor and street lighting is to set up an effective rate classification or rebate system. For Los Angeles, an effective rebate structure was put in place to account for the energy savings resulting from the installation of LEDs across the City. The process involved working

with the local utility, the Los Angeles Department of Water and Power.

A rebate per fixture replaced was established with the utility to reflect the energy savings as a result of installing LEDs. The rebate is calculated based on the lower wattage of the LED fixtures. The rate for an existing street light is adjusted as the retrofits are implemented and the savings are monitored and managed using a GIS database.

Education and awareness is an important element of advanced outdoor lighting initiatives. In Los Angeles, the retrofit program has been generally well received and feedback from the community continues to be positive. Initially, the City expected opposition to the colour change from yellow to white light. As part of the LED program, the City undertook a comprehensive outreach and awareness program about the energy cost and GHG saving opportunity. With this information, City staff found that residents became largely indifferent to the change in light colour.

As well, the City actively worked with various City agencies, such as the Los Angeles Police Department (LAPD), to evaluate how LEDs could enhance municipal services and safety. For the LAPD, enhancing night-time illumination in high-crime areas of the City was seen as a benefit of the white light from LEDs. The air division of the LAPD has already found that the LED replacement program has created a continuous and evenly dispersed white light effect that enhances law enforcement.

Communicating the wide range of benefits and advantages of advanced outdoor lighting technologies early on can help residents make informed decisions and contribute to public support. As well, engaging municipal agencies and departments from the outset of a conversion program can also encourage champions to come forward and support an energy efficiency and lighting replacement program.

More Information

Contact details:
Ed Ebrahimian
General Manager/ Director
Bureau of Street Lighting
City of Los Angeles
213-473-3231

Website: http: //bsl.lacity.org/

4.2 Adaptive Lighting Applications

City of Toronto

Overview

With the publication of the 2006 Ontario Building Code, an update was made to allow the use of motion-controlled lighting devices in large buildings (including apartment buildings) and in parking areas for all new construction. In response, the City of Toronto amended the Property Standards Chapter (629) of the Toronto Municipal Code to permit to the installation and use of motion sensor lighting in areas such as building corridors and parking garages.

Before the amendment, the Toronto Municipal Code standard effectively prohibited the use of motion-sensor-controlled lighting, because of a standard for large buildings requiring minimum light levels to be maintained at all times for safety reasons. Lighting could not be dimmed or turned off when an area was not in use.

Context and Drivers

When the Ontario Building Code was updated in 2006, energy-efficient building practices, including the use of light and motion sensors, were incorporated. The Ontario Building Code serves as the primary code for the construction and retrofitting of all buildings. The process for granting a building permit in Toronto requires applicants to comply with the Ontario Building Code during the construction process. On completion of construction and prior to occupancy, a building must also comply with the Toronto Municipal Code.

This resulting two-stage process led to limitations on the uptake of adaptive lighting technology. For instance, with the 2006 Ontario Building Code update, motion-controlled lighting was permitted. However, the Toronto Municipal Code restricted the use of this technology in occupied multi-storey buildings. This regulatory conflict created confusion in the development and property management community.

The Greater Toronto Apartment Association, the Toronto Atmospheric Fund (TAF), and other stakeholders recognized the discrepancy between the Ontario Building Code and the Toronto Municipal Code and recommended an update to the property codes for the City of Toronto. However, City Councillors were concerned that the use of adaptive lighting controls could undermine public safety. To demonstrate the safe use of the technology, TAF coordinated three pilot projects using motion sensor controls in municipally owned parking garages. These pilot projects, together with surveys of the site users, helped to convince stakeholders that adaptive lighting controls could be deployed safely and responsibly.

An amendment to the Toronto Municipal Code was proposed in July 2009. Following extensive consultation with stakeholders, including the police and fire departments, property owners and tenants' associations, the amendment was revised and approved by Council in August 2010. The amendment includes detailed design requirements to ensure the safety and comfort of the public. Permitting the use of motion sensors in the Toronto Municipal Code was identified as an important opportunity to introduce control technologies that would increase energy savings and reduce GHG emissions. With the new policy completed, plans are in place to install LEDs and motion-sensor controls in 30 municipally owned parking garages across the City.

The City of Toronto, in partnership with the Toronto Atmospheric Fund and Toronto Hydro, is also actively testing LEDs through four LED street lighting pilot projects and one adaptive street lighting pilot project.

Lessons Learned

Updates to a lighting code should not conflict with an existing code or standard. When developing municipal property standards, an important step is the evaluation of policy congruence with applicable building codes and other regulatory requirements. The standards of the Illuminating Engineering Society of North America (IESNA) now include recommendations for lighting designers and code evaluators about reducing conflicts when developing codes for alternative outdoor lighting strategies. Policy makers should review all existing policies, regional and municipal building and property codes, and international standards (IESNA, IDA) before drafting a lighting strategy to ensure compliance with the most up-to-date industry standards.

Pilot projects can help demonstrate the safety and efficacy of new policies and technologies. In this case, special pilot approvals allowed the City of Toronto to test public and stakeholder reaction to adaptive lighting controls before amending local regulations to allow their widespread use. In many cases, initial opposition to new approaches and technologies are based on lack of experience and information and can be resolved through demonstrations and pilots.

The legal implications of adaptive lighting remain a concern for policy makers. Adaptive lighting applications, particularly the use of light and motion sensors, are quickly becoming common practice in buildings across Canada to reduce unnecessary energy consumption. The wider application of adaptive controls for street lighting, parking lots, and parking garages is still being evaluated and concerns remain about the perception of safety and the potential for liability caused by under-illumination or the creation of dark public spaces.

Relevant stakeholders for a lighting policy should be engaged through a community consultation process. All affected members of the public (property owners, building occupants, tenants, and police and fire departments) should be engaged early on in the policy development process to discuss safety implications of introducing adaptive techniques. Local data and literature should be reviewed to determine if there is any connection between light levels and crime rates or traffic accidents. Appropriate regulations and design standards can ensure that adaptive controls are used in a way which does not undermine the public safety or comfort. The most important strategy for minimizing liability concerns is having a clear policy specifying when, where, and how adaptive controls can be used.

Although community members may be interested in saving energy and reducing the need for lighting, local opinion may focus on concerns about safety, reliability, and aesthetics. Engaging stakeholders and regulatory bodies early on can help establish a broad base of support and streamline the regulatory process.

Municipal tools for the regulation of land use, safety, licensing and property standards can indirectly limit the use of advanced outdoor lighting. In Ontario, the application of the Ontario Building Code (OBC) sets precedents for the design, operation, and overall quality of built structures. The OBC is concerned primarily with safety in terms of the standards used for construction. The enforcement of building codes falls to municipalities.

Municipalities can also establish property standards bylaws to enforce basic standards, good maintenance, and safety as permitted by the *Ontario Building Code Act*. The City has updated its property standards to minimize conflicts that prevent the introduction of new technologies, such as motion sensors and adaptive lighting.

For Toronto, changes were made to require minimal light levels at all times in areas providing access to exits. This requirement can be met through bi-level light fixtures, emergency lighting fixtures, or by excluding some fixtures from the motion sensor system.[9] By adjusting the standard, the use of motion sensors remained a valid option for the control of lighting and energy costs.

More Information

Contact details:
Warwick Perrin
Policy and Research Consultant
Policy and Planning Services
City of Toronto
416-392-8096

For the full lighting policy: See Appendix D - Municipal Lighting Policies for LEDs and Adaptive Lighting

[9] In Toronto, emergency lighting can be used for normal lighting conditions and for emergency situations. Where emergency lighting is used for a dual purpose, a second and separate power circuit is required that can supply power to a limited number of fixtures for a predetermined time during a general power failure.

City of Ottawa

Overview

The City of Ottawa developed a Right-of-Way Lighting Policy in 2006/2007 (updated 2009) to clarify the range of permitted types of lighting, determine appropriate lighting levels in various outdoor contexts, and identify areas where changes to the existing street light system were warranted. The policy deals with lighting standards for roadways and sidewalks within public rights-of-way and was developed using the Illuminating Engineering Society of North America (IESNA) *RP-8 Roadway Lighting* guide. The policy examines the cost implications of various recommended right-of-way lighting approaches where they differ from existing standards with respect to installation costs, on-going maintenance, and energy efficiency. The policy is also leading to the uptake of more energy-efficient lighting, such as LEDs, through the development application process.

Context and drivers

In 2001, the communities of West Carleton, Nepean, Kanata, Ottawa, Vanier, Gloucester, Cumberland, Osgoode, Rideau, Goulbourn, and the Regional Municipality of Ottawa-Carleton were amalgamated to establish the City of Ottawa. Immediately following amalgamation, the City of Ottawa assessed the variety of outdoor lighting standards and established a harmonized street lighting policy.

From 2003 to 2005, the City undertook a comprehensive update to the harmonized lighting policy. City activities related to lighting harmonization were placed on hold while staff examined a range of lighting opportunities that should be considered in the formation of a new policy, including the burial of hydro and telecommunication cables, right-of-way lighting issues such as the need for lighting design consistency, cost savings from different lighting fixtures, and lighting issues associated with street design.

One of the first directives, following the amalgamation of the City Council, was to undertake community engagement when a new policy was to be introduced or an existing policy updated. To review the new street lighting policy, a technical advisory committee and a public advisory committee were established. The public was invited to attend open houses and meetings at City Hall. Although the City adhered to IESNA standards for lighting levels, the advisory committees helped identify the types of fixtures that could be used, evaluate where outdoor lighting was necessary, and ensure that heritage and crime prevention issues were taken into consideration. The public engagement process allowed members of the general public, special interest groups, community groups, and business associations to provide input on the development of the Right-of-Way Lighting Policy.

Recognizing that energy prices would increase in the future and that two-thirds of the street lighting operating budget was used for energy, the City crafted the policy to allow for potential changes in technology to save energy and associated costs. The City is already experiencing marginal energy demand reductions as a result of the harmonization of street lighting practices of the former municipalities, which were exceeding IESNA standards. Because of the lower light output, the City assumes that less energy is being used.

In response to the varying international standards for street lighting, the City of Ottawa has relaxed the requirement to meet IESNA standards, where appropriate, for certain areas of the City, as part of road redevelopment or replacement and as part of a

new development application for a subdivision. In taking this unusual step, the City has taken the stance that not all areas of a municipality require similar lighting levels. More detailed information on the approach being taken by Ottawa is outlined in the Right-of-Way Lighting Policy provided in Appendix D.

Lessons Learned

Establishing a comprehensive lighting policy is not a common practice in Ontario. In Ontario, municipalities are now beginning to expand beyond standard land-use planning practices to control lighting and develop comprehensive lighting policies. The approach taken by the City of Ottawa to develop a right-of-way lighting harmonization policy focused on addressing the concern about liability, while encouraging a higher level of commitment among City departments to coordinate the application of advanced outdoor lighting strategies. For instance, the City of Ottawa Planning Department has undertaken to ensure that light pollution is minimized in new developments as part of a site plan agreement.

The City is also evaluating the potential to encourage the uptake of LEDs and adaptive lighting as part of municipal property standards. The establishment of a lighting policy can contribute to the wider uptake and acceptance of innovative lighting practices, such as the use of more energy-efficient lighting.

Alternative lighting standards can be part of an advanced lighting policy. The City adopted a policy that specified light levels to be half the level set by the IESNA for local residential streets, excluding mixed-use areas. For local residential streets, City officials decided that the IESNA standards were not required. When it came time to update the lighting policy, the City consulted with its legal advisors and identified that there were no regulations pertaining to the requirement for outdoor street lights in Ontario. Municipalities are not obliged to follow the standards set by IESNA, and may create their own standards to address local requirements.

The process of developing a policy should engage key stakeholders, such as the local Business Improvement Areas (BIAs) and Community Associations, to provide suggestions and insights on cultural, economic, and other community issues that extend beyond technical requirements for lighting.

Lighting policies should encourage innovation and improvements in existing technology and standards. To further reduce energy use and costs, the City of Ottawa has launched a pilot project that incorporates the use of LED streetlight fixtures. The pilot project was installed first on pedestrian-scale lighting fixtures on a major urban arterial roadway. Tests for roadway scale fixtures are expected in the near future.

The Right-of-Way Lighting Policy developed by the City does not limit the use of new technologies that could contribute to lower lighting costs, better illumination, and other benefits to the City. The policy outlines that, at the discretion of the City, approved lighting technologies can be substituted. As well, the policy takes into account the need to update the approved technology list on a regular basis to account for LEDs and adaptive technologies. The policy also encourages flexibility so that multiple lighting fixture designs, adaptive techniques, and light level standards different from those set by the IESNA can be adopted by the City. Outdoor lighting policy should be developed to accommodate improvements in technology and innovative adaptive lighting techniques.

Municipalities and local utilities can use third-party entities to validate cost savings. Most street lighting in Ottawa is unmetered. With the installation of LED fixtures and the lowering of standard lighting levels, it is expected that the City will use less energy. To accurately capture these savings, the City of Ottawa and Ottawa Hydro are working with the Standards Council of Canada Compliant Laboratories to evaluate the energy consumption and use of new lighting technologies in use across the City. The Compliant Laboratories will confirm the average level of energy consumption over the life of the product. With this information on energy use, an adjustment can be made to capture the potential reductions in energy demand and associated energy costs with more energy-efficient lighting technologies.

More Information

Contact details:
Scott Edey
Program Manager
Street and Community Lighting
City of Ottawa
613-580-2424 ext 23197

Website:
http://www.ottawa.ca/residents/planning/design_plan_guidelines/completed/lighting/index_en.html

Full the full lighting policy visit:
http://www.ottawa.ca/residents/planning/design_plan_guidelines/completed/lighting/row_lighting_en.pdf

City of Vancouver

Overview

The City of Vancouver is among the first communities in Canada to install both LED and adaptive street lighting technologies. The program was implemented in Yaletown, a neighbourhood with increasing pedestrian activity. The Yaletown district was selected to showcase the technology during the 2010 Winter Olympics and address the below-industry-standard lighting levels for the area.

The program was a success and allowed the City to highlight the application of LEDs and adaptive streetlight fixtures, attain the minimum standard lighting levels required for the neighbourhood, and achieve energy savings by adjusting light level output to reduce energy consumption during non-peak hours.

Context

The LED and adaptive lighting initiative was launched by the Greenest City Action Team (GCAT), a group of experts brought together by the City of Vancouver Mayor Gregor Robertson with the goal of making Vancouver the Greenest City in the World by 2020.

The GCAT recommended showcasing a demonstration street lighting program as part of the Olympics. This led City staff to work with regional partners to identify a suitable location for the pilot, including the 2010 Olympic Organizing Committee, the local utility (BC Hydro), and the Yaletown Business Improvement Association (BIA).

The incorporation of the Yaletown BIA into the lighting initiative allowed the City to address local business concerns about low-level lighting in the neighbourhood and to establish the BIA as champion for the use and application of LEDs and adaptive street lighting in commercial areas.

During implementation of the lighting program, the BIA worked closely with the City to minimize the impacts of construction while the new lighting was being installed. The BIA directed an awareness and outreach program to property owners and tenants.

Another important contributor to the program was BC Hydro. During the lighting upgrade, BC Hydro provided a grant to help offset some of the costs of the lighting upgrade and also conducted light level measurements and proof-of-performance evaluations, measured energy savings, and ensured the final lighting designs met IESNA standards.

The lighting program included the use of remote monitoring and control capacities. These features allow City staff to control dimming times from a central location.

Lessons Learned

Energy pricing may not (yet) allow for a competitive business case for LEDs and adaptive lighting technologies. Because of the special nature of the demonstration project for the 2010 Vancouver Olympics, the City of Vancouver was able to obtain funding for new technologies – in this case, the combination of LEDs and adaptive technology in the same fixture. The funding was slightly different from that normally available through the Power Smart Program. (Power Smart is an initiative of the British Columbia electric utility company BC Hydro that promotes conservation in the province. The program focuses on reducing energy use for residential, commercial, and industrial customers.) In order to expand the program to other parts of the City using

Power Smart, a grant for the new technology had to be established. Currently, because of electricity costs in the region, the cost savings are insufficient to generate a reasonable payback period or business case for LEDs. Furthermore, additional savings achieved for adaptive technologies are captured by the reduced maintenance costs of the fixtures, which do not transfer back to the utility, and therefore are not reflected in the rebate structure. The city is still investigating new LED products to create a business case, as the industry matures and product prices decline.

The pilot project showed the importance of alternative rates or tariffs for LEDs and adaptive street lighting. The costs of implementing new outdoor lighting technology can be a challenge. For the City of Vancouver, incentives were needed to help establish a business case. There are higher upfront capital costs to implementing LEDs and adaptive lighting at this time relative to other technologies in the market place. Typically, the higher costs can be covered by the energy cost savings, with payback periods varying depending on the region and the local energy pricing context. Regions where electricity costs are high will find it easier to make a business case for updating to a new technology; however, regions where electricity costs are low may not be able to realize a payback period without changes to electricity rates or tariffs for LEDs and adaptive lighting.

The initiatives of the City of Vancouver and other British Columbia communities have demonstrated to BC Hydro the importance of creating a separate tariff structure to accommodate adaptive lighting and LEDs. Properly capturing the energy savings from the use of LEDs and adaptive street lighting can be a challenge in communities where flat rates are charged for electricity and no net metering is in use. BC Hydro has advanced to develop a program that helps municipalities set up, track, and monitor adaptive lighting and a separate blended average tariff to account for reduced power use for lighting.

In certain cases, cost-sharing agreements or the establishment of separate processes for tracking and monitoring energy use and associated tariff charges between a municipality and local utility may have to be developed. Issues surrounding the ownership of the light fixtures; the costs of implementation, testing and maintenance; and decisions about who retains the energy cost savings need to be resolved if the utility is not owned by the municipality, but maintains an inventory of street lights on behalf of a municipality.

Proper commissioning of LED and adaptive lighting is part of achieving maximum lighting and energy cost savings. BC Hydro is currently measuring the actual light levels achieved by the updated LED streetlights in the Yaletown district to ensure that the new fixtures are performing to expected standards. Once new standards and retrofits are completed, on-the-ground measurement should be considered to ensure light levels are actually performing to expected standards and specifications.

More Information

Contact details:

Phil Wong
Superintendent
Electrical Design and Support Services
City of Vancouver
604-871-6686

5 Overcoming Common Challenges to Implementing LEDs and Adaptive Lighting

Despite growing interest in the application of LEDs and adaptive lighting technologies, municipalities continue to face challenges in adopting these technologies to achieve their energy and GHG reduction objectives. Overcoming these challenges, particularly those in the market uptake of LEDs and adaptive lighting, will require innovative approaches to engaging community support, securing funding, and demonstrating reduced capital expenditures.

Work with the community

Many of the challenges experienced with initiating LED and adaptive lighting programs or policies result from a lack of public awareness about how LEDs and adaptive lighting can contribute to meeting a community's energy and sustainable development goals. Public perceptions and expectations about outdoor lighting directly influence the types of technologies and standards that can be adopted by a municipality. Engaging key stakeholders can help build awareness and develop a base of support for changes to municipal outdoor lighting policy.

A common approach undertaken by each of the profiled municipalities was the engagement of public-sector agencies that could identify important stakeholders and initiate discussion among various parties. Successful public engagement activities involve:

- posting signage and contact information around new LED or adaptive lighting installations and requesting feedback;
- distributing background information online through dedicated websites;
- conducting focus groups with local residents and businesses;
- developing, distributing, and collecting surveys of residents and business in pilot project areas;
- holding community information sessions;
- establishing public advisory committees.

Build knowledge, know-how, and technical skills

Keeping informed on the latest advancements in the application of LED and adaptive lighting technologies is a challenge. Community planners, engineers, architects, builders, developers, government officials, and the general public may not be familiar with LED and adaptive lighting technologies and how these technologies can benefit municipalities and businesses.

For instance, consultants with limited experience of LEDs might fail to recommend the technology to developers, or might apply "conventional rules of thumb" when evaluating the efficiencies and effectiveness of the technology. Tours of successful pilot projects are an effective way to involve community stakeholders, from local business leaders to councillors, and familiarize them with the technologies involved. By visiting new or retrofit programs in other communities, local leaders can talk to their counterparts who have successfully implemented an outdoor advanced lighting initiative.

Another common strategy applied by communities to develop support and buy-in is the use of demonstration projects. Demonstrations provide an opportunity to evaluate a range of technologies, reduce investment risk, learn more about the applications, and develop a business case. For example, the demonstration project in the City of Ottawa provided an opportunity to evaluate the concerns and issues of various agencies responsible for road safety and emergency response. An

issue management approach was established to identify concerns and appropriate corrective and remedial actions. In Los Angeles, the initial demonstration projects for LEDs provided an opportunity to evaluate technologies and actively engage the public through consultation. The information from the demonstration project was used to inform the business case in illustrating the net benefit from energy cost savings to the City and developing the phasing and roll out of the program across the city based on public and stakeholder feedback.

Partner to overcome project financing and program risk

Reducing investment risk is an important consideration for the startup and ongoing application of advanced outdoor lighting initiatives. The right partnership can help put the development of an LED and adaptive lighting program on the right financial path.

A significant upfront capital investment is required to implement LEDs or adaptive lighting technology. Typically, these costs can be recovered through energy cost savings; however, payback periods vary according to the regional and local energy pricing context. Areas in which electricity costs are high will experience faster pay-back periods. Where electricity costs are low, the ability to justify LED and adaptive lighting could require drawing on other forms of justification, such as GHG emissions reductions.

Even when a reasonable return on investment relative to project implementation can be demonstrated, external financing may be required to ensure the success of a project. Many municipalities are securing financing through financing and loan arrangements with development corporations or utilities. In Ann Arbor, a one-time grant was available, provided that energy savings would be reinvested in the community. In Los Angeles, the local utility provided a loan that was expected to be recovered through energy cost savings.

Another approach used by municipalities is to undertake a project in phases. For instance, Ottawa began with a pilot replacement project for LEDs. If the pilot is successful, a program could be rolled out into neighbourhoods as the budget allows. Los Angeles has also been very successful in phasing the implementation of street lighting projects. Phasing in LEDs also allows municipalities to benefit from improvements in technology or reductions in price. However, each phase should be large enough to allow the municipality to benefit from economies of scale, which is significant for LED technology.

Ensuring congruency among codes and standards

Implementing new technology or updating an existing outdoor lighting policy may conflict with lighting standards already in place. There is no requirement to follow any of the identified international standards for outdoor lighting. Generally, municipalities and utilities follow standards set by IESNA.

In certain cases, it might be desirable to follow standards other than those of IESNA to save energy or mitigate light pollution. In other cases, updating a municipal code may cause it to conflict with a provincial code. To avoid conflict, all applicable codes or standards that apply to lighting should be reviewed before a technology is implemented or a policy is updated.

To assist with this process, an advanced outdoor lighting committee might be formed to bring together a variety of departments and agencies of a municipality that influence outdoor lighting activities, including personnel from special events, planning, architecture and urban design, heritage, police, fire, parks and recreation, culture, and others.

Establish Rates or Tariffs to Capture Energy Savings

While the benefits of LEDs and other adaptive lighting strategies are compelling, challenges to encouraging wider uptake remain. Across North America, the level of energy and cost savings of LEDs and adaptive street lighting programs vary dramatically relative to use, weather conditions, and lighting standards. One of the biggest challenges is adequately capturing the cost savings of LEDs. Most local utilities do not separate the operation and maintenance benefits of LEDs or adaptive lighting in rate schedules for different lamp types. This is an acknowledged industry-wide barrier to encouraging the market uptake of the technology by utilities and municipalities.

Capturing the savings of LEDs and adaptive street lighting is largely a matter of billing. Most street lights are unmetered and, generally speaking, utilities recover energy costs for the electricity on a flat per-pole rate. The rates vary according to the type of technology used. Because LEDs do not have standard wattages, and since wattages of LED are not directly comparable to conventional lighting systems, which require ballast that adds 30 percent to the rated wattage, most utilities cannot properly price municipalities for LED installations. Energy cost recovery is even more challenging for adaptive street lighting, given the need to account for dimming schedules, the level by which lighting is being lowered, and the amount of energy saved (since the control system also uses energy). Some dimming systems have meters, but they tend not to be utility-grade.

The cities of Los Angeles, Ottawa, and Ann Arbor have all worked with their respective utilities to establish appropriate energy rates for either LED or adaptive lighting systems to account for the energy cost savings.

An important starting point for creating a competitive environment for LEDs and adaptive street lighting is to work with a local utility to establish a rate or tariff. The process for confirming the rate or tariff might require a pilot study for different technologies and applications of LEDs and adaptive lighting. This approach was undertaken in Los Angeles, Ottawa, and Ann Arbor.

In certain cases, cost-sharing agreements might need to be established between the municipality and local utility before a rate or tariff can be introduced. This type of situation is likely to occur if a utility is maintaining a set of street lights on behalf of a municipality or there is uncertainty between a utility and municipality about how to allocate energy cost savings relative to capital investments and maintenance costs for street lights.

6 Quick Starting Municipal Lighting Polices and Supportive Actions for LEDs and Adaptive Lighting

Decisions related to LED and adaptive lighting techniques occur at all stages of policy planning, development, implementation, cooperation, and consultation across different departments and with multiple stakeholder groups. Establishing and implementing effective policy and supportive actions can involve gathering evidence and data, undertaking financial and policy analysis, building a business case to convince a council and community members, and building a network of support. To help with the process, this section presents a series of policies and supportive actions for use in developing advanced outdoor lighting initiatives.

6.1 Policy Instruments and Supportive Actions

A number of resources are available to municipal policy-makers and decision-makers that can support the application of advanced outdoor lighting.

In general, policy instruments range from voluntary agreements and moral suasion, to mandatory instruments, such as legislation. The choice of policy instrument or supportive actions varies according to factors such as the nature and source of demands for change, economic and social considerations, legal issues, cost, evidence of effectiveness, political feasibility, and administrative capability.

Table 1 outlines policy instruments and supportive actions divided into three categories: (1) actions a municipality can take as a corporation (leading by example), (2) actions a municipality can encourage others to take (partnerships and incentives), and (3) actions a municipality can compel others to take (regulation).

Many of the suggested policies and actions can be undertaken simultaneously and can provide mutual support for LEDs and advanced outdoor lighting. The implementation of any one policy or supportive action will depend on local conditions. A brief overview of each of the policy instruments and supportive actions is provided.

Table 1: Summary Table of LED and Adaptive Lighting Policies and Supportive Actions

Policy Instruments and Supportive Actions	Municipal Example	Lead Role			Outcome
		Municipality	Local Utility or developer	Community	
Leading By Example					
Develop a business case	Ann Arbor Los Angeles	✓			Secure a loan or funding for upfront capital investment. Pay back loan with energy cost savings.
Use demonstration and pilot projects	Ann Arbor Los Angeles Vancouver Ottawa	✓	✓		Use pilot projects to test new technology and form partnerships.
Set conservation goals	Ann Arbor Los Angeles Vancouver	✓			Use political will as a driver. Link outdoor lighting to other environmental initiatives (e.g., GHG Action Reduction Plans and Community Energy Plans).
Partnerships and Incentives					
Partner to improve project financing	Ann Arbor Los Angeles Vancouver Ottawa	✓	✓		Secure a loan or funding for upfront capital investment. Pay back loan with energy cost savings.
Work with the community	Los Angeles Ottawa	✓		✓	Build a broad base of support for energy efficiency and engage local champions.
Set street lighting rates or tariffs for LED fixtures and adaptive street light controls	Ann Arbor Los Angeles Vancouver Ottawa		✓		Ensure that municipalities benefit financially from the reduced energy use of LEDs and/or adaptive street lighting.
Regulation					
Amend the Official Plan		✓			Establish broad goals and objectives for lighting, including energy efficiency.
Amend Zoning Bylaws	Ann Arbor Los Angeles Ottawa	✓	✓		Include lighting in a community zoning bylaw and give direction on energy efficiency.

Policy Instruments and Supportive Actions	Municipal Example	Lead Role			Outcome
		Municipality	Local Utility or developer	Community	
Use site plan control	Ann Arbor Los Angeles Ottawa	✓	✓		Make certain technologies a requirement for new developments.
Use the development permit systems		✓			Make certain technologies a requirement for new development.
Use plans of subdivision	Ann Arbor ☐os Angeles	✓	✓		Make certain technologies a requirement for new development.
Use Community Improvement Plans (CIPs)		✓			Direct financial support towards energy efficiency improvements, including lighting infrastructure.
Include in municipal property standards	Toronto	✓			Include energy efficiency options or regulations in property codes.
Develop outdoor lighting policies	Ottawa	✓			Include energy efficiency options or regulations in an outdoor lighting policy.

Business Case

An important starting point for the development of any lighting strategy in a community is the ability to outline the value proposition or business case for the new technology.

In Ann Arbor, the opportunity to advance an LED lighting retrofit program was not strictly based on cost effectiveness and energy savings. The case also included contributing to the revitalization of a downtown area. The City of Los Angeles was successful in developing a business case for converting 140,000 cobra-head streetlights to LEDs. Two years after launching the retrofit program, the City of Los Angeles has already realized annual cost savings of $1 million within an electricity cost budget of $17 million, with an expected payback period of less than seven years.

Most business cases for lighting are based on the ability to capture capital costs within a reasonable period of time. Net present value, internal rate of return, and simple payback period are measurements that can be used to make a business case.

Demonstration and Pilot Projects

Developing acceptance for large-scale applications of relatively new technologies such as LEDs and adaptive lighting can benefit from a demonstration project. A demonstration project is aimed at assessing the merits of developing a widespread use of an approach. A demonstration project can help stakeholders gain confidence for a concept and focus on the development of a "proof of concept."

Most demonstration projects involve a relatively small number of customers or a limited outdoor lighting test area that represents

the business requirements of a project. The cities of Los Angeles, Vancouver, Ann Arbor, and Ottawa all started their comprehensive LED or adaptive lighting programs with targeted demonstration projects. In some cases, the demonstration projects were directed at street lighting for which a municipality was responsible. In other cases, demonstrations were done with developers in new communities.

Conservation Goals

The benefits of reduced electricity consumption and GHG emissions associated with implementing advanced outdoor lighting technologies can be used to support the development of policies or as a policy driver for the advancement of LEDs and adaptive lighting technologies. The cities of Los Angeles, Vancouver, and Ann Arbor were successful in gaining public appreciation, political support, and external project funding by communicating GHG and energy savings to stakeholders.

Partnering to Improve Project Financing

Reducing investment risk and obtaining affordable capital for advanced outdoor lighting projects can be a challenge. To make a successful business case, it is important to secure appropriate financial agreements with stakeholders and take advantage of funding opportunities from external sources. Funding opportunities come in the form of grants, government energy efficiency programs, downtown renewal programs, business interest associations, or rebates from a utility for a technology that has demonstrated energy savings.

Financial or cost-sharing agreements can also be worked out between the municipality and a utility, especially if some of the outdoor street lighting infrastructure is owned by the utility. Los Angeles, Ann Arbor, Vancouver, and Ottawa all successfully negotiated cost-sharing agreements and/or secured project funding from external programs.

Working with the Community

Public awareness of the potential benefits of LEDs and adaptive lighting are important. In Ottawa, emergency services personnel were concerned about the use of adaptive lighting, such as dimmable street lights, in the case of an emergency on a roadway. City staff worked with local energy services to demonstrate the use of the technology and implement safety protocols to increase lighting during an emergency.

In Los Angeles, extensive public consultation was undertaken on the colour of LED lights and the environmental benefits. As the city-wide lighting retrofit has advanced, residents and local agencies, including the Los Angeles Police Department, have become supporters of LED technology.

Street lighting rates or tariffs for LED fixtures and adaptive street light controls

Establishing rates or tariffs that adequately capture the energy cost savings provided by LEDs and adaptive street lighting is important for making a business case. The cities of Los Angeles, Ottawa, and Ann Arbor, in partnership with their respective utilities, developed appropriate energy rates for either LEDs or adaptive lighting systems to account for the energy cost savings. The onus is on municipalities to initiate these discussions, as local utilities do not proactively offer preferred rates for these technologies.

Official Plans

Municipal official plans outline growth objectives and guide the future land use planning of a community. Energy-related policies

can be included in an official plan. Broad goals and objectives for lighting, light levels, and efficiency can be part of this document.

Zoning Bylaws

Zoning bylaws, which state how land will be used in a community and outline requirements for building use, density, height, size, and location, can be used to promote lighting efficiency. A lighting section may be incorporated into a community's zoning bylaw. Lighting plans, specification for fixtures, and planning light levels can all be part of a zoning bylaw and incorporated into a site plan control process.

The common types of lighting installations that municipalities regulate through zoning and other tools include parking lot lighting; street lighting; the lighting of gas stations, associated convenience stores, and exterior sales areas; performance facilities; security lighting; illumination of building facades and landscaping; illuminated signs; illuminated walkways, park areas; and outdoor parking garages. A municipality may want to create "lighting districts" that have different lighting regulations and criteria. A lighting district might be a zoned district or several zoning districts that have similar lighting needs.

Examples of comprehensive lighting regulations and their application are outlined in lighting manuals and guidelines, including the *Outdoor Lighting Manual for Vermont Municipalities*[10] and the online website Zoning Trilogy. The Zoning Trilogy provides over 1554 definitions for zoning; 374 zoning provisions; and over 70 illustrated zoning diagrams for the control and regulation of various activities, including outdoor lighting.[11]

Los Angeles and Ann Arbor have made the inclusion of LEDs part of site plan approval.

Site Plan Control

Municipalities use site plan control to ensure that certain requirements are met before a site is developed. No development can occur before the community reviews and approves the plan. Once approved, a site plan agreement outlines terms by which the developer must abide. A site plan control by-law can enable a municipality to approve the design and technical aspects of a proposed development to ensure it is attractive, functional, and compatible with the surrounding area or planned context. By including lighting considerations in site plans, communities can promote energy efficiency, including the use of energy-efficient equipment, such as LEDs or adaptive lighting for outdoor lighting.

A detailed example of a site plan that references the use of energy efficiency is provided for the City of Toronto in Appendix D.

Development Permit Systems

Development permit systems combine site plan control, zoning, and minor variances in one application format, thereby expediting and simplifying the application process. They promote development by providing for faster timelines, eliminating duplication, incorporating flexibility for uses and development standards, and providing a "one-stop" planning service. Development permit systems can be used to promote energy efficiency and can include the encouragement of more energy-

[10] A detailed overview of common approaches for developing lighting policies and regulating lighting through zoning by-laws is provided by Kathleen Ryan and Michael J. Munson (1996), *Outdoor Lighting Manual for Vermont Municipalities*, produced for the Chittenden County Regional Planning Commission.

[11] *The Zoning Trilogy*, available at: www.zoning trilogy.com. Accessed March 18, 2011.

efficient design and guidance for the use of LEDs and adaptive lighting.

Plan of Subdivision

A plan of subdivision is used when dividing land into two or more lots intended for separate ownership. It outlines the details and conditions required for development. The approval process includes considerations of where streets, parks, and dwellings will be located, as well as servicing issues related to storm and sanitary sewers and protection of natural features.

A municipality can encourage energy efficiency through a plan of subdivision, including the use of LEDs and adaptive lighting. Specifying technologies for outdoor lighting as part of a plan of subdivision should be included in either a lighting policy or roadway outdoor lighting design guide. Los Angeles, Ann Arbor, and Ottawa have all evaluated the potential to require specific lighting requirements as part of a plan of subdivision.

Community Improvement Plans (CIPs)

Community improvement plans target a designated area within a city for development or redevelopment. Because each community faces unique challenges and opportunities, there is no predetermined concept of what a community improvement plan should be or include. CIPs can provide incentives or loans to developers to achieve the desired outcome, and they may include changes to land use and zoning regulations. CIPs can be used to support energy efficiency in a community, including the use of LEDs and adaptive lighting.

Municipal Property Standards

Municipalities can ensure uniform standards for the condition and maintenance of properties, and establish safeguards for the safety, health, and welfare of occupants through property standards. In some cases, property standards may limit the use of energy-efficient equipment. At the same time, municipal standards can be used to promote energy efficiency if it can be related to the safety, health, and welfare of occupants.

In Toronto, changes were made to municipal property standards to reduce conflicts between encouraging energy efficiency as outlined in the Ontario Building Code and safety considerations in the municipal property standards.

Outdoor Lighting Policy

Municipalities can benefit by designing and implementing an outdoor lighting policy. The policy can set illumination levels, provide standards for streetscape aesthetics, and even regulate energy efficiency measures. The City of Ottawa has successfully implemented an outdoor lighting policy that provides guidance on illumination levels as well as the use of advanced outdoor lighting technologies, including LEDs and adaptive lighting. With the adoption of the policy, other departments and agencies in Ottawa are evaluating opportunities to apply the policy to their respective activities, such as including measures as part of site plan control and approval.

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Appendix A: Annotated Glossary and General Information

This appendix provides a brief overview of the key regulating bodies governing outdoor lighting in Canada, specifically relating to street lighting, parking garages, parking lots, and pedestrian walkways. The glossary also provides definitions of key terms relating to lighting levels, adaptive lighting technologies, and LED models. An accompanying matrix provides a technical overview of the specific policies, standards, guidelines, and codes that currently apply to outdoor lighting.

Lighting Organizations and Associated Standards

International Dark-Sky Association (IDA)

The IDA has provided guidance on selecting efficient outdoor lighting and creating local lighting ordinances that help reduce the hazards of light pollution since 1988. It sets lighting level limits in compliance with IESNA standards. IDA recommends that light levels and uniformity ratios not exceed recommended values as required by IESNA RP-8, RP-33 and R-20.

IDA's goals are to be an effective educator in stopping the adverse environmental impact of light pollution on the natural environment by building awareness of the problem and solutions. IDA publishes guides and handbooks for municipalities on how to develop appropriate lighting codes or ordinances. The IDA does not manufacture lighting fixtures, but does evaluate and endorse commercial products that meet its criteria, specifying preferred lighting types.

IDA Outdoor Lighting Code Handbook focuses primarily on how to reduce light pollution as well as on strategies for developing appropriate lighting codes and ordinances. According to the IDA, the goal of creating an effective lighting code is the elimination of the adverse effects of outdoor lighting, such as light trespass, glare, energy waste, and sky glow. A good lighting code is a vital step toward these goals, but achieving them requires effective implementation and enforcement of the code on an ongoing basis.[12]

The IDA has also developed "Lighting Zones" (LZ0 to LZ4) describing different ambient lighting conditions.[13] Lighting limits have been suggested for each LZ zone in order to help reduce the negative effects of light pollution.

- LZ0: No ambient lighting. This includes areas where the natural environment will be seriously and adversely affected by lighting. When not needed, lighting should be extinguished.
- LZ1: Low ambient lighting. This includes areas where lighting might adversely affect flora and fauna or disturb the character of the area. Lighting may be used for safety and convenience, but need not be uniform or continuous. After curfew, lighting may be extinguished or reduced as activity levels decline.
- LZ2: Moderate ambient lighting. This includes areas of human activity where the vision of human residents and users is adapted to moderate light levels. Lighting may typically be used for safety and convenience but it need not be uniform or continuous. After curfew (typically within two hours of sunset), lighting may be reduced as activity level declines.

[12] International Dark Sky Association (2000). *Outdoor Lighting Code Handbook Version 1.14.*

[13] DMD and Associates Ltd. (2009*) Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities,* prepared for the Union of Nova Scotia Municipalities (UNSM).

- LZ3: Moderately high ambient lighting. This includes areas of human activity where the vision of human residents and users is adapted to moderately high light levels. Lighting is generally desired for safety, security, and convenience and it is often uniform and continuous. After curfew, lighting may be reduced as activity level declines.
- LZ4: High ambient lighting. This includes areas of human activity where the vision of human residents and users is adapted to high light levels. Lighting is generally considered necessary for safety, security, and convenience and it is mostly uniform and continuous. After curfew, lighting may be reduced in some areas as activity levels decline.

Illuminating Engineering Society (IESNA)

IESNA has a diverse membership that includes engineers, architects, designers, educators, students, contractors, distributors, utility personnel, manufacturers, and scientists. IESNA works cooperatively with a variety of related organizations to produce publications identifying national guidelines and standards for all types of lighting. For example, IESNA has produced the *Lighting Handbook*, a nationally recognized document for industry professionals seeking technical information on lighting. The handbook includes explanations of concepts, techniques, applications, procedures and systems, as well as detailed definitions, tasks, charts and diagrams.[14]

IESNA has set a precedent in Canada and the United States for the use of their standards and guidelines. If a municipality does not comply with the national standards recommended, the municipality may put itself at risk for litigation in accidents involving roadway lighting safety.[15]

Below is an overview of the most relevant IESNA standards and guidelines relating to outdoor lighting in North America.

IESNA RP-8 is the American National Standard Practice for Roadway Lighting. This document is the primary source for the design of roadway lighting throughout North America and provides design guidelines for lighting roadways, adjacent bikeways, and pedestrian ways. The 2005 IES RP-8 was reviewed and its content reaffirmed in 2010.

IESNA RP-20 is the recommended practice for Lighting for Parking Facilities. The recommendations serve as a guideline for designing fixed lighting for parking facilities. Methods of enhancing personal security and for deterring vandalism, while conserving energy and minimizing maintenance, are also addressed. The recommendations are considered *minimum* guidelines and can be subject to change based on sound engineering judgment. The lighting recommendations in this practice do not apply to public roads, bikeways, walkways, curb parking along streets, or airport parking.

IESNA RP-33 is the recommended practice on Lighting Exterior Environments. The recommendations serve as a comprehensive guide for all exterior lighting. The practice focuses primarily on visual issues such as glare, visual acuity, and illuminance; community responsive design and design guidelines; security

[14] Illumination Engineering Society of North America Webpage, accessed at: http://www.iesna.org/ on February 9, 2011.

[15] Sage Consulting Engineers (2007) *Improved Street Lighting Study for Green House and Safety Benefits, Institutional and Technical Review*, prepared for the Western Australian Local Government Association and the Sustainable Energy Development Office.

lighting; stray light and lighting ordinances; luminaire types and classifications; and energy conservation and maintenance.[16]

As part of RP-33-99, IESNA has adopted Lighting Zones (E1-E4) developed by the International Commission on Illumination (CIE) describing different ambient lighting conditions. Lighting limits have been suggested for each zone to help reduce the amount of light trespass. The zones are:

- Zone E1: Areas with intrinsically dark landscapes. Examples are national parks, areas of outstanding natural beauty, areas surrounding major astronomical observatories, or residential areas where inhabitants have expressed a strong desire that all light trespass be strictly limited.
- Zone E2: Areas of low ambient brightness. This includes suburban and rural residential areas where activity is generally low. Roadways may be lighted to typical residential standards.
- Zone E3: Areas of medium ambient brightness. This includes urban residential areas where nighttime activity is generally higher. Roadway lighting will normally be to traffic route standards.
- Zone E4: Areas of high ambient brightness. Normally these are urban areas that have both residential and commercial use and experience high levels of nighttime activity.

IESNA G-1-03 is the recommended practice for Security Lighting for People, Property, and Public Spaces. The practice sets guidelines for the design and implementation of outdoor lighting to enhance the security of people, property, and public spaces. This publication is intended for property owners and managers, crime prevention specialists, and law enforcement and security professionals. "This document is intended to provide specific guidelines where it has been determined that security is an issue, and where security is an important determining factor in the design or retrofit of a given property."[17]

IESNA G-2-10 is a guideline that offers basic information for lighting designers on the application of LEDs for interior and exterior illumination. The guideline describes LED technology and lighting performance, explains the differences in measurement methods for LEDs compared to traditional sources, and offers design guidance for general lighting applications.[18]

Lighting Research Centre

The Lighting Research Centre (LRC), part of the Rensselaer Polytechnic Institute, is a university-based research centre that focuses on all types of lighting. The university offers graduate education in lighting and provides training programs for government agencies, utilities, contractors, lighting designers and other lighting professionals.

In regards to outdoor lighting, the LRC investigates effective new technologies and equipment that provides cost-effective energy improvements and minimizes light pollution. For example, the Transportation Lighting Program at the LRC explores new guidelines for improving lighting visibility, safety and security on

[16] DMD and Associates Ltd. (2009) *Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities*, prepared for the Union of Nova Scotia Municipalities (UNSM)

[17] Illuminating Engineering Society of North America (IESNA) Security Lighting (2003). *IESNA G-1-03 - Guideline on Security Lighting for People, Property, and Public Spaces*, New York, NY.

[18] Illuminating Engineering Society of North America (IESNA) LED Lighting (2010). *IESNA G-2-10 - Guideline for the Application of General Illumination 'White' Lighting Emitting Diode (LED) Technologies*, New York, NY.

vehicles, roadways and in the workplace.[19] The LRC produces technical papers and makes recommendations on a variety of topics relating to outdoor lighting, including the potential health impacts and visibility benefits of different types of lights or promoting the use of LED technologies to gain widespread market acceptance.

Model Lighting Ordinance (MLO)

The International Dark Sky Association and the Illuminating Engineering Society of North America formed a Joint Task Force to develop a Model Lighting Ordinance to help address the issue of consistent outdoor lighting regulation in North America.[20] The MLO will also be designed to guide municipalities in evaluating new and existing lighting systems for energy use, skyglow, and light trespass as well as enforce building codes that pertain to lighting. The MLO is under public review and will include an accompanying Design and User's Guide.

Royal Astronomical Society of Canada (RASC)

The Royal Astronomical Society of Canada (RASC) was incorporated within the province of Ontario in 1890 and was federally incorporated in 1968.[21] The RASC is devoted to the advancement of astronomy and includes members from many countries. The Society is unique in accepting both professional and amateur astronomers as members. The RASC is an advocate of the IDA and the two organizations are working together to educate Canadian municipalities on ways to promote responsible lighting and to reduce light pollution. The RASC does not set standards or guidelines for outdoor lighting in Canada. It does, however, publish papers promoting responsible outdoor lighting approaches that influence and advise local, provincial, and national governments and organizations.

Transportation Association of Canada (TAC)

The TAC is a national association with a mission to promote safe, secure, efficient, and environmentally sustainable transportation services in Canada.[22] TAC promotes current guidelines relating to roadways in Canada and provides examples of relevant and current examples from around the world. One of TAC's strategic objectives is to continue to develop and update guidelines for road and road-related matters, including safe and efficient street lighting guidelines. The TAC is responsible for developing and refining new lighting applications for Canadian Roadways.

The publications produced by TAC serve as a valuable resource for the transportation industry. In 2006, the TAC updated the Roadway Lighting Design Guide, which reviewed current standards and research around the world.[23] The guide also reviewed and commented on practices of the CIE, IES, AASHTO, and the CSA. The TAC adopts current standards developed by the IES as they are widely accepted throughout North America. The updated guide included a section on new technologies and concepts relating to roadway lighting such as LED's, adaptive lighting techniques and solar power lighting.

[19] Lighting Research Center webpage, accessed at: http://www.lrc.rpi.edu/ on February 9, 2011.
[20] International Dark-Sky Association webpage. accessed at www.darksky.org on February 9, 2011.
[21] Royal Astronomical Society of Canada webpage, accessed at: http://www.rasc.ca/ on February 9, 2011.

[22] Transportation Association of Canada website, accessed at: http://www.tac-atc.ca/english/about/index.cfm on February 9, 2011.
[23] McLean, D. (2007) *Design of Roadway Lighting* (TAC Ottawa Spring 2007) PowerPoint presentation accessed at: http://dmdeng.com/pdf/learning/DMD_TAC_Lighting_Presentatation.pdf on February 9, 2011.

National Building Codes

ASHREA Standard 90-1

The ASHREA Standard 90-1 is a national energy code for all buildings, except low-rise residential buildings. New versions of Standard 90-1 are issued every three years, so that the latest version will be available in major code revisions. The energy code promotes the use of energy efficient interior and exterior lighting in commercial and high-rise residential buildings. The energy code requires manual or automatic controls or switches that allow occupants to dim lights or turn them off as needed. The code requires that all exterior lighting have automatic controls and turn off automatically when daylight is available. Lights in parking garages, tunnels, and other large covered areas that must be on during daylight hours are exempt from this requirement.

Model National Energy Code for Buildings (MNECB)

The Model National Energy Code for Buildings establishes national minimum standards of construction for building components and features that affect a building's energy efficiency. The MNECB is not a mandatory standard for Canadian municipalities. However, if it is adopted or referenced by a province, territory, or municipality, the provisions of the MNECB can become the building standard in that jurisdiction.[24] The MNECB is intended to be used in conjunction with the National Building Code (NBC). The intent of the MNECB is to eliminate inefficient practices and ensure that all buildings maintain a minimum standard of energy efficiency.

[24] Natural Resources Canada (1999) *Introduction to the Model National Energy Code for Buildings*.

Provincial Building Codes

Provincial Building Codes

The purpose of a provincial building code is to establish consistent minimum standards to be followed by the construction industry within a given province. Once the codes are adopted, they become the legal regulations for construction in that province and are enforced by the province. The code applies to new building construction as well as to renovation to an existing building and includes both residential and commercial projects. All provinces follow the National Building Code as their standard, with some making modifications to suit the province.

For example, the Ontario Building Code (OBC) administered by the Ministry of Municipal Affairs and Housing, Building and Development Branch works with the municipal and building sectors and consumer groups to improve and streamline the building regulatory system. The OBC governs the construction of new buildings and the renovation and maintenance of existing buildings with specific guidance on interior and exterior lighting. In June 2006, the Ontario Provincial Government passed regulation 349/06, which amended the Ontario Building Code with section 12.2.2.1, to include motion-controlled lighting in apartment building common areas.

Municipal Codes and Standards

Municipal Codes

Municipal Codes are a compilation of bylaws organized by subject that are created and enforced to maintain the health and safety of a community. For example, the Property Standards Chapter 629-36 of the Toronto Municipal Code provides standards relating to outdoor lighting for buildings in Toronto. The Property Standards chapter deals primarily with interior lighting for buildings, but also includes standards for parking lots, walkways,

stairs, porches, verandas, loading docks, and ramps. The code states that the areas immediately outside buildings must maintain a minimum level of illumination at ground level.

Toronto Green Standard

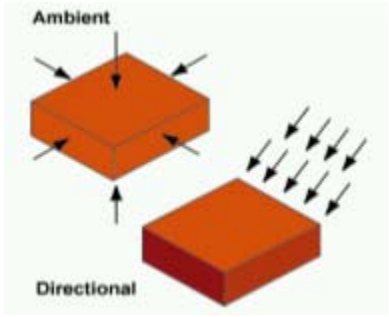
The Toronto Green Standard (TGS) is a set of performance measures with supporting guidelines and some potential strategies relating to sustainable site and building design for new development (residential and non-residential). The light pollution section sets guidelines to reduce night-time light trespass from buildings. As of January 31, 2010, all planning applications for new development are required to meet Tier 1 performance measures and targets, which address environmental issues such as air and water quality, greenhouse gas emissions, energy efficiency (including lighting standards), solid waste and the natural environment. Developers may also chose to meet Tier 2, a voluntary higher level of environmental performance, and be eligible for a development charge refund of 20 percent.

New planning applications, including Zoning By-law Amendment, Site Plan Control and Draft Plan of Subdivision received on or after January 31, 2010, are required to meet Tier 1 of the Toronto Green Standard.

In the attempt to reduce light pollution, the TGS has set two requirements for Tier 1. All buildings must install exterior light fixtures that are shielded to prevent glare and light trespass onto neighbouring properties. The standard also restricts up-lighting from exterior light fixtures. All light fixtures are required to be efficient while providing a minimum illumination level sufficient for personal safety and security (the minimum level is not specified, but the lighting must comply with the Toronto Municipal Code). The TGS suggests several potential strategies for achieving the minimum Tier 1 requirements. The strategies include using motion sensor lighting, installing building automation systems, and installing fixtures that effectively project light downward.

Terms and Definitions

Ambient Lighting: Ambient lighting is a general illumination that comes from all directions in a room that has no visible source. This type of lighting is in contrast to directional lighting, which is made up of a light source with parallel light rays that do not diminish with distance.



Candela: A unit of luminous intensity, formerly known as a *candle*. One candela equals one lumen per steradian (angle of the cross-section of a simple cone).

Color rendering: Effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant

***Efficacy*:** Efficacy is a ratio of the amount of light produced by a light source (usually measured in lumens), to the amount of power consumed to produce it (usually measured in watts),[lumens/watts].

Extinguish: To extinguish a light source means to turn it off completely.

High Intensity Discharge (HID) Lighting: HID fixtures have been predominantly used throughout Ontario and continue to be the most widely available in the lighting industry. The basic HID lamp styles are metal halide, low-pressure sodium, high-pressure sodium, and mercury vapour. In the late 1980s, Ontario's energy efficiency programs replaced the existing mercury vapour street lights with more energy-efficient high-pressure sodium lights. At that time, the high-pressure sodium lamps did increase energy efficiency, lower operating cost savings, and lower maintenance costs due to longer operating lifespans.

Induction Lighting: Induction lights have virtually no lamp parts to wear out because they do not use traditional electrodes or filaments, but instead use a magnetic field to excite gases to transmit energy. Induction lighting is very energy efficient and has an extremely long life expectancy, projected at 100,000 hours.[25]

Luminance: The luminance of a roadway surface is the intensity of reflected light per unit area of the surface in the direction of the viewer. Luminance indicates the "brightness" of the roadway surface ahead of the observer when viewed from a given location in a given direction.

***Illuminance*:** Illuminance is the intensity of light that falls on a surface. The primary unit of measurement for illuminance is the lux, which is measured in units of lumens/m^2. Illuminance is often used in design criteria, standards, and regulations related to lighting, as it can be easily measured in the field. Standards are usually framed in terms of either average illuminance levels, or minimum illuminance levels. Minimum illuminance refers to the darkest unshaded area of a site.

Light Emitting Diode (LED): LEDs are solid-state semiconductor devices that convert electrical energy into visible light.

Light Pollution: Light pollution is the combined effects of glare, light trespass, and sky glow. In some cases, light pollution can actually reduce the safety and security it is intended to provide, since light may be directed where it was not intended. The associated energy waste is costly in terms of public expenditures, quality of life, and the environment.

Light Trespass: Light trespass occurs when light from an outdoor fixture goes where it is not wanted. Light trespass can be a subjective judgement, because it is difficult to define when, where and how much light is unwanted. Many standards require that fixtures and lamp types point downwards in order to reduce light trespass.

Lighting Curfew: During periods of low traffic or pedestrian flow typically from dusk to dawn, lighting curfews use technology to turn off or dim selected parts of lighting systems. Benefits of implementing lighting curfews include cost savings, reduced impact on the environment, and lower levels of light pollution.

LM-79-08 Electrical and Photometric Measurements of Solid-State Lighting Products: LM-79-08 is a standard set by the Illuminating Engineering Society (IES) that prescribes uniform test methods for LED fixture manufacturers, using fixtures as they would be manufactured for production. This term is used in purchasing LED lights.

[25] Local Authority Services (2008) *Ontario's Guiding Lights 'Street Lighting' Addressing Energy Efficiency & the Environment.*

*LM-80 Measuring Lumen Maintenance of LED Light Source*s*:* LM-80 is a standard set by the Illuminating Engineering Society (IES) that prescribes uniform test methods for measuring LED lumen maintenance. This term is used in purchasing LED lights.

Lumen: Lumen is a measure of the brightness of light. One lumen is the amount of light that falls on an area of one square foot, every point of which is one foot from the source of one candela. The difference between lux and lumen is that lumen is a measure of brightness only, whereas lux is a measure of brightness divided by a specific area on the ground. Lux = lumens ÷ area.

Lumen Depreciation: Lumen depreciation is a decrease in lumen output that occurs over the lifetime of the lamp, as a lamp is operated. All types of electric light sources experience lumen depreciation due to a variety of factors. This is important to understand when selecting adaptive lighting techniques.

Lumen Maintenance: Lumen maintenance is a measure of how well a light source maintains its lumen output over time, typically shown as a percentage of initial light output.

Luminous flux: Luminous flux is the measure of the perceived power of light, which differs from the measure of total power of light. Luminous flux is adjusted to reflect the varying sensitivity of the human eye to different wavelengths of light. For example, an instrument may measure the total brightness of light for two different wavelengths and register them as being the same brightness. However, the human eye will perceive one wavelength to be brighter because of the way the human eye processes light. The metric Luminous Flux was developed to account for this.

Lux: Lux is a measure of brightness of light over a specific area. The difference between lux and lumen is that lumen is a measure of brightness only, whereas lux is a measure of brightness divided by a specific area on the ground. Lux = lumens ÷ area.

Security Lighting: Security lighting is intended to protect people and property from criminal activity and to create the perception of security. IESNA G-1-03 provides specific guidelines pertaining to security lighting.

Sky Glow: Sky glow is the wide-scale illumination of the night sky caused by artificial light that is seen over most cities and towns. It is more commonly referred to as light pollution.

Uniformity: Uniformity refers to the evenness of the distribution of light on surface(s). In determining uniformity, minimum, average, and maximum illuminances are compared using ratios. Uniformity ratio is the ratio of the brightest spot to the dimmest spot, or the ratio of the average brightness to the minimum brightness and varies depending upon the application. This ratio is used to ensure the lit area is uniformly lit.

Appendix B: Existing Municipal Standards for Outdoor Lighting

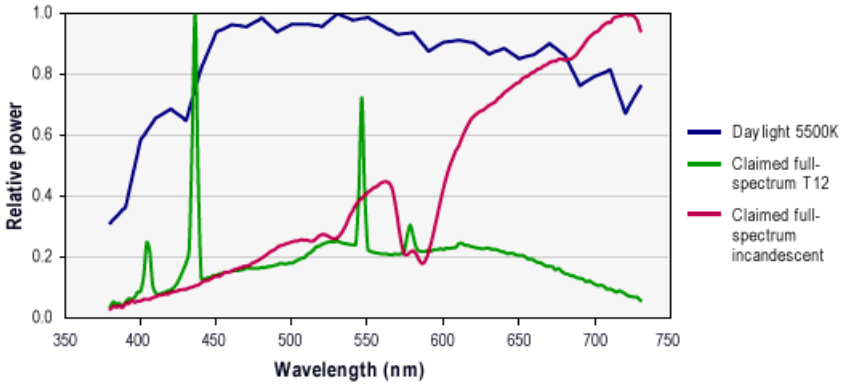
Outdoor Lighting Standards and Codes						
Regulating Body	**Policies, Standards, Codes, or Regulations Relating to Outdoor Lighting**	**Lighting Types**	**Minimum Illumination Levels**	**Energy Efficiency**		**Use of Adaptive Lighting Strageties**
				Supportive	**Unintended Impediments**	
International Dark-Sky Association	The IDA sets lighting level limits in compliance with IESNA standards. IDA recommends that light levels and uniformity ratios should not exceed recommended values as required by IESNA RP-8, RP-33 and R-20. The IDA has developed five Lighting Zones (LZ0 to LZ4) describing different ambient lighting conditions. Qualitative lighting limits have been suggested for each zone. The IDA recommends that commercial properties in non-urban commercial zones be lighted to 25,000 lumens per acre; for projects in residential zones be lighted to 10,000 lumens per acre. For residential properties in suburban areas the recommended light levles are 50,000 lumens per acre cap, and in urban areas is 100,000 lumens per acre. Light levels should not exceed recommended values as set by the IESNA RP-33 and RP-20. (Guidelines for Good Exterior Lighting Plans, The International Dark Sky Society 2009)	The IDA recommends the use of compact fluorescent or high pressure sodium unless the light is motion sensor activated, in which case they recommend incandescent or instant start compact fluorescent bulbs. Metal halide and light sources rated over 3000K are discouraged, and outdated mercury vapor are prohibited. (Guidelines for Good Exterior Lighting Plans, The international Dark Sky Society 2009)	The IDA follows minimum standards set by the IESNA for Roadway lighting (RP-8), Parking Facilities (RP-20-98) and Exterior Lighting Environments (RP-33).	The IDA promotes the use of appropriate and efficient lighting technologies which reduce the amount of light trespass, glare and energy waste.		
Illuminating Engineering Society of North America (IESNA)	RP-8 establishes a minimum lighting level for roadway lighting based on the type of roadway and level of pedestrian conflict. The higher the level of pedestrian conflict, the higher the level of lighting recommended. The IESNA RP-8 Average Maintained Illuminance by Pedestrian Conflict Area; Major Roads between 18 lux (low activity) to 34 lux (high activity), Collector Roads between 12 lux (low) to 24 lux (high), Local Roads between 8 lux (low) to 18 lux (high). The IESNA RP-20-98 Minimum maintained illuminance level for parking lots is 2 lux and the maximum to minimum ratio is 20:1 for basic parking lots. For areas of enhanced security the minimum maintained level is 5 lux and maximum to minimum ratio is 15:1. The IESNA RP-33 for Lighting Zones Pre-Curfew; E1: 1 lux, E2: 3 lux, E3: 8 lux, E4: 15 lux. Post Curfew; E1: 0 for systems not intended for public safety or security, 1 lux otherwise, E2:1 lux, E3: 2 lux, E4: 6 lux. IESNA-G-1-03 (when security is an issue) illuminance level for parking facilities, garages and covered parking spaces is 60 lux; for parking lots is 30 lux, park trails and walkways is 6 lux, and likely loitering areas is 10 lux. The illuminance level for major retail parking lots is 30 lux. The typical mounting height for pedestrian zones is in the 3 to 6 m (10 to 20 ft) range. The typical mounting height for pedestrian path zones is 60 to 105 cm (24 to 42 inches). Within the building zone, building floodlighting can be employed as a security lighting technique. Luminaire setback position from the building façade should be three-fourths the height of the building for uniform lighting; and the spacing should not exceed twice the setback. Local ordinances should be consulted to determine if this lighting technique is allowed.	The IESNA typically recommends compact fluorescent or High Pressure Sodium due to their high efficacy and long life span.	The minimum illumination levels vary between regulations and standards (as identified in RP-8, RP-20, RP-33 and G-1-03).		By setting minimum illumination levels, many municipalities apply higher than required levels in order to satisfy and go beyond the required levels to reduce the risk of litigation. This typically results in over lighting.	The IESNA is supportive of applying adaptive lighting strategies including light dimming. Lighting standards produced by the IESNA and TAC allow for lighting levels to be varied based on the level of pedestrian activity/conflict which can be proven to be reduced in later hours of the evening. The updated version of IESNA RP-8 will define and recommend Adaptive Lighting strategies.

Regulating Body	Policies, Standards, Codes, or Regulations Relating to Outdoor Lighting	Lighting Types	Minimum Illumination Levels	Energy Efficiency		Use of Adaptive Lighting Strageties
				Supportive	Unintended Impediments	
Model National Energy Code for Buildings (MNECB)	The use of reflective paving should be considered as a possible alternative to the installation of more lighting fixtures or higher powered lamps (as recommended by IESNA RP-8). Exterior Lighting shall be controlled by lighting schedule controllers, photocells, or a combination of both. Lighting schedule controllers shall be of the automatic type or otherwise capable of being programmed for 7 days and for seasonal daylight schedule variations. Controls to permit lower lighting levels at night are required for office spaces. Where night lighting controls are required, at least one fixture shall be controlled separately from the remaining fixtures to provide a minimum level of light for safety purposes.	Exterior Lighting must be high efficacy. Efficacy of compact fluorescent lamps shall be determined according to CSA-C861 Standards.	Lamps for exterior lighting shall have an initial luminous efficacy of not less than 60 lumens per watt determined according to accepted good practice.	The new MNECB promotes energy efficient buildings with particular attention to limiting unnecessary exterior lighting and enforcing smart lighting requirements.		The MNECB promotes the use of adaptive lighting strategies by identifying strategies that promote the use of motion sensor lighting, limiting vanity lighting, and using fixtures that effectively project light downwards.
Ontario Building Code	Recently amended section 12.2.2.1 to permit the use of motion sensor controlled lighting in the exterior and common areas for apartment buildings. Section 12.3.4.11 suggests that lighting for exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during night time hours. The lighting shall be controlled by a time switch or photosensor.	Fluorescent light ballasts shall meet or exceed the minimum ballast efficacy factors required by Supplement Standard SB-10 (all fluorescent lamp ballasts must have a minimum power factor of at least 0.9 of indicated voltage).	The Building Code states (Table 12.3.4.10 Exterior Lighting Power Densities) that the maximum power density for uncovered parking should be 1.6W/m2, walkways should be 2.2W/m2 and parking near 24hr retail entrances should be 800 W per main entry.	The recently amended section 12.2.2.1 of the Code permits motion sensor controlled lighting in the common areas of apartment buildings.		Section 12.2.2.1 permits motion sensor controlled lighting in the common areas of apartment buildings.
Toronto Municipal Code Section 629-36	A. Adequate artificial light required to maintain the level of illumination shall be provided at all times. B. (1) (e) Illumination from lighting shall be provided to average levels of not less than 10 lux at floor or tread level. C. For parking lots, walkways, stairs, porches, verandas, loading docks, ramps or other similar areas, a minimum level of illumination of 10 lux at ground or tread level shall be provided.	The Code does not specify what types of lighting may be used, but that they maintain a minimum level of illumination.	The Code requires that parking lots, walkways, porches, veranda, loading docks, ramps have a maintained minimum of 10 lux; and that public areas and garages have a maintained minimum of 50 lux.		Until a recent ammendment to the TMC, Chapter 629, Property Standards, prohibited the use of motion sensor controlled lighting in the common areas of existing buildings.	An amendment has been approved by the City of Toronto Council to allow the use of motion senor controls.
Toronto Green Standard (TGS)	The Toronto Green Standard is performance oriented to achieve flexibility so that innovation is encouraged to meet performance targets. For example the standard aims to achieve 25% energy savings above the Model National Energy Code. Tier 1 requires that all new buildings must install exterior light fixtures that are shielded to prevent glare and light trespassing onto neighbouring properties. Tier 1 also requires that no up-lighting from exterior light fixtures be allowed unless otherwise permitted through a heritage designation.	The external lighting of building features, known as 'vanity' or 'architectural' lighting, should be eliminated at best or projected downwards. Event lighting, such as spotlights and searchlights should be prohibited during the migratory seasons.	All light fixtures are required to be efficient while providing a minimum illumination level sufficient for personal safety and security.	New planning applications including; Zoning By-law Amendment, Site Plan Control and Draft Plan of Subdivision received on or after January 31, 2010, are required to meet Tier 1 of the TGS.		The TGS suggests using motion sensor lighting and building automation systems as potential strategies for energy reduction.

Appendix C: Visibility Benefits and Health Concerns Associated with Full Spectrum Lighting

Full-spectrum light is light that covers the electromagnetic spectrum through near-ultraviolet; sunlight is considered full spectrum. Full-spectrum lighting for indoors or outdoors tries to imitate the same quality of light that we receive from the sun. It has been found that when people are exposed to such lighting, they can be more productive. Another advantage of full-spectrum lighting is a higher quality colour rendering. Certain lights, such as fluorescents or LEDs, emit light so that it appears to be the same quality as sunlight; however, they emit spectral rays that are radically different, as can be seen in the figure below.

Figure 1: Lighting Power Comparison



Source: Lighting Research Center http://www.lrc.rpi.edu/

The main concern related to full-spectrum lighting is the short wavelengths emitted by these lights. These rays are close in wavelength to ultraviolet light, which, after prolonged exposure, can cause premature aging or cancer. However, all of the available literature on the subject states that the full-spectrum lighting is not harmful for people, but more detailed studies on this issue are needed.

Appendix D: Municipal Lighting Policies for LEDs and Adaptive Lighting

Toronto Municipal Code for Motion Sensors

Authority: Licensing and Standards Committee Item 32.1,adopted as amended, by City of Toronto Council on August 25, 26 and 27, 2010
Enacted by Council: August 27, 2010

CITY OF TORONTO
BY-LAW No. 974-2010
To amend City of Toronto Municipal Code Chapter 629, Property Standards,
respecting motion controlled building corridor and garage lighting.

The Council of the City of Toronto HEREBY ENACTS as follows:

1. Chapter 629, Property Standards, of The City of Toronto Municipal Code is amended as follows:

A. The following definitions be inserted in alphabetical order in § 629-1, Definitions: ACCESS TO EXIT — The same meaning as in Article 1.4.1.2. of Division A of the Building Code, that is noted as follows for reference purposes only and is subject to Subsection C:

(1) ACCESS TO EXIT — That part of a means of egress within a floor area that provides access to an exit serving the floor area.

EXIT — The same meaning as in Article 1.4.1.2. of Division A of the Building Code, that is noted as follows for reference purposes only and is subject to Subsection C:

(1) EXIT — That part of a means of egress, including doorways, that leads from the floor area it serves to a separate building, an open public thoroughfare or an exterior open space protected from fire exposure from the building and having access to an open public thoroughfare.

MOTION SENSOR CONTROLLED SWITCH — An electrical control device activated by movement within a defined area, for the purpose of operating one or more electrical fixtures.

NULL ZONE –— Where the artificial lighting for a space is controlled by one or more motion sensors, a portion of the space that does not receive sensor coverage from a motion sensor.

B. Section 629-36, Lighting, be amended by adding the following:

H. Motion sensor controlled switches.

(1) All interior lighting installed to provide the minimum level of illumination required by this chapter may be on circuits controlled by motion sensor controlled switches, except where the lighting circuit is:

(a) For an exit, including, an exit stairway.

(b) Required to conform to Subsection B(2)(d).

(c) For emergency lighting.

(2) A motion sensor controlled switch permitted under Subsection H(1) shall:

(a) Be designed for fail-safe operation so that if the motion sensor controlled switch fails, the electrical fixture that it controls activates.

(b) Be of a type, the operation of which is not impaired by the presence of smoke.

(c) Control an area that is not more than 240 square metres.

(d) If the illumination is for an access to exit:

[1] Maintain an average level of illumination of 10 lux at all times.

[2] Except as required under Subsection H(2)(d)[1], maintain the illumination within its area of control active for not less than 15 minutes after the activity that caused the lighting to activate has stopped or left its area of control.

(e) If the illumination is for a space that is an access to exit from a residential area:

[1] Activate all lighting between vertical partitions in the space.

[2] Activate all lighting within the space within two seconds of any movement either in or directly related to the area controlled by the motion sensor control switch.

(f) Provide coverage to all of the space so that there are no null zones.

ENACTED AND PASSED this 27th day of August, A.D. 2010.

DAVID R. MILLER, Mayor

ULLI S. WATKISS City Clerk

City of Ottawa Right of Way Lighting Policy

TBC

City of Toronto Site Plan Control By-Law – Additional Site Plan Control Powers