Task Force to Study Lighting Efficiency & Light Pollution in Maryland

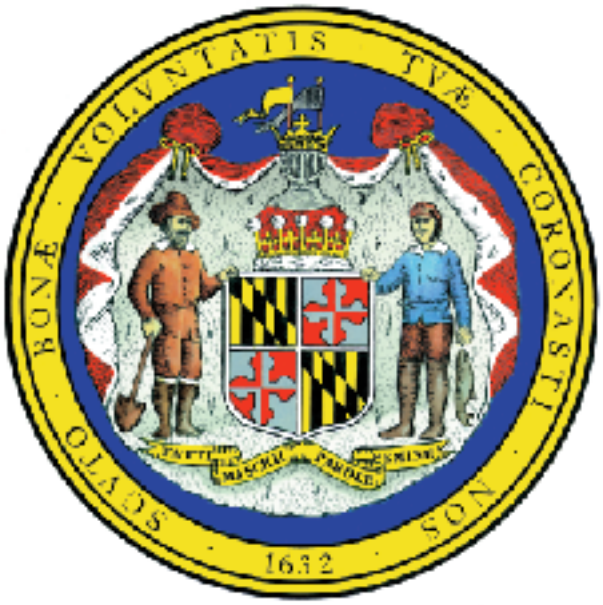

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Table of Contents

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Executive Summary

Purpose

House Joint Resolution 14 of 2001 Regular Session of the Maryland General Assembly created the "Task Force to Study Lighting Efficiency and Light Pollution in Maryland." The purpose of the Task Force was to study the cost, extent, and consequences of inefficient public lighting and light pollution in the State, and the benefits of alternative improvements.

Background

The objective of any outdoor lighting system is to maximize visibility in performing a given task, while minimizing the amount of energy and associated costs used in producing the light. Effective outdoor lighting provides many benefits. It can be used to increase pedestrian and vehicular safety, enhance a community's nighttime character, advertise commercial businesses and provide security. Appropriately designed and properly installed, outdoor lighting contributes to the safety and welfare of residents, customers and visitors. A well-designed lighting system should produce no more lighting than is necessary for a given task and direct the light only where it is needed. Inappropriately designed outdoor lighting applications in both rural and urban areas can result in glare, over lighting, light escalation, sky glow and wasted energy. "Light pollution" is the term used to describe the undesired consequences of inappropriate outdoor lighting, such as sky glow, light trespass and glare. As our population increases, light pollution becomes an increasing problem.

Outdoor lighting is an integral part of our communities. It is used to light our homes, streets and commercial facilities. The following illustrates the variety of applications and areas of consideration:

- Roadways - State, County and Municipal
- Commercial, Institutional and Government Buildings
  - Parking Lots
  - Walkways
  - Building Surfaces
- Residential Areas
  - Streets
  - Housing
- Parks and Public Recreational Areas

There is no single best answer to achieve efficient/cost effective lighting because there are numerous appropriate applications and equipment technologies. The following are some general guidelines coming out of the Task Force's deliberations:

- Choose luminaires that distribute the light only where it is needed, minimizing light pollution and unnecessary energy consumption.
- Choose appropriate lamp source color.
- Choose lamp types to maximize visibility per lumen output, as well as maximizing lumen output per input watt of energy.
- Choose lamps with longer life ratings.
- Choose appropriate efficient ballasts.
- Design to appropriate lighting levels based on Illuminating Engineering Society of North America (IESNA) recommendations and to avoid over lighting.
- Layout lights to avoid spillover onto adjacent property, and choose appropriate pole heights.

State agency implementation of these general guidelines will help design lighting systems that perform their intended function without wasting energy or causing light pollution, while minimizing installation, energy and maintenance costs.

This report represents the summary of issues and recommendations of the Lighting Efficiency and Light Pollution Task Force. As the Task Force members concluded their work, they hoped their efforts would achieve three objectives:

(1) Reduce or stop the spread of sky glow;
(2) Reduce or halt the increase of light trespass or glare; and
(3) Conserve energy and minimize the State's energy costs.

The members of the Task Force met seven times from September 2001 to February 2002, and worked diligently to explore this complex subject. Their efforts, and those of a number of interested citizens, resulted in a compilation of valuable technical and policy information along with a variety of recommendations and options for enhancing lighting efficiency and reducing light pollution in Maryland.

Recommendations of the Lighting Efficiency and Light Pollution Task Force

The many issues of outdoor lighting are often complex. As with similar kinds of issues, there is no single or simple solution. While newer technology exists that would drastically reduce light pollution, the costs to retrofit or replace all existing fixtures would be prohibitive. Still, there are significant opportunities with new construction to help achieve the general objectives of efficient energy usage, reducing or halting the spread of light pollution and increasing overall efficiency of the existing lighting infrastructure. Beginning with State agencies setting the example, the State should require where possible, and encourage elsewhere, the use of properly designed light systems. While not being proscriptive, the state should to help educate the development community on proper outdoor lighting systems and assist jurisdictions in adopting adequate standards into local regulations.

State Departments and Agencies, and the University System of Maryland should analyze their outdoor lighting systems and practices and develop a plan for bringing all state-owned or state-maintained outdoor lighting into compliance with applicable outdoor lighting standards. The

plan should seek to bring existing lighting systems and fixtures into compliance within the next six years, where it is economically feasible to do so. All new lighting systems and fixtures should comply with applicable outdoor lighting standards.

The Maryland Green Buildings Council, established by Executive Order 01.01.2001.02 and chaired by the Secretary of the Department of General Services, should report on implementation of these plans, and recommend a public information program, aimed at local planning officials, county commissions, city councils, etc., with the following objectives:

- Bringing to their attention the nature, causes, and effects of inefficient outdoor lighting; Informing them of the existence of national guidelines and standards (IESNA), National Electrical Manufacturers Association (NEMA) designed to provide efficient and effective outdoor lighting; and encouraging them to adopt local outdoor lighting ordinances consistent with IESNA/NEMA standards.

- To the extent possible and appropriate, the State should engage the cooperation and assistance of the Maryland Association of Counties, the Maryland Municipal League, and the Baltimore and Metropolitan Washington Councils of Governments in this effort.

- The Maryland Green Buildings Council should recommend a public information program, aimed at Maryland architects, builders, and lighting contractors, with the following objectives:

    - Bringing to their attention the nature, causes, and effects of inefficient outdoor lighting;

    - Informing them of the existence of national guidelines and standards (IESNA, NEMA) designed to provide efficient and effective outdoor lighting; and

    - Encouraging them to develop site designs and install outdoor lighting systems consistent with existing IESNA/NEMA standards.

- To the extent possible and appropriate, the State should engage the cooperation and assistance of IESNA, NEMA and others in this effort.

That the State of Maryland should consider financial incentives, in the form of tax credits, grants, or interest-free financing, to businesses and local governments to retrofit or replace existing noncompliant outdoor lighting systems with compliant fixtures and systems.

In implementing these recommendations, the following should be taken into consideration:

- IESNA recommendations for lighting levels and uniformity should be used wherever possible.

- Local jurisdictions should be encouraged to adopt standards based on IESNA criteria and develop means to enforce the standards. Building codes are one possible vehicle for

implementing standards. Any deviation from the adopted standards should be justified through public forum.

- Cutoff type luminaires should be used wherever possible and appropriate. Light allowed to project skyward is wasted, both from an energy standpoint, and relative to maintaining a dark sky.

- Over lighting should be discouraged strongly in both the public and private sectors. In order for performance to be maintained or enhanced, participation must be across the board.

- Safety must be addressed as the primary concern, and lighting installed for aesthetic purposes cannot be designed in such a way as to jeopardize safety.

- Standards should be as simple and general as possible. A local jurisdiction should not be limited in their efforts to address safety concerns.

- Mandatory standards compliance should be implemented on State funded projects.

- Standards set by local jurisdictions should not jeopardize the availability of Federal funds on a project. Standards should apply to new construction and major renovation/rehabilitation work. Trying to upgrade all existing systems would not be practical or cost effective.

- Residential, low wattage and airport lighting systems on the runway side should be exempted from any standards established. Temporary lighting systems, such as is used for holidays or at nighttime work areas also should be exempted, but nonetheless, effort should be made to achieve energy efficiency and control of light.

Finally**,** to help implement the above Recommendations, the Task Force also recommends taking the following procedural actions:

- The State should lead by example and require that all outdoor lighting as part of the design of any new or major renovation of any State owned or leased facility should follow Lighting System Design Guideline. These guidelines should be based upon IESNA and NEMA standards and promulgated by the Maryland Green Buildings Council.

- To assist with education and outreach to both local governments and the development community, the State should produce materials that describe the issues of light pollution and contain information regarding the design of appropriate outdoor lighting systems. These materials should be available **by July 1, 2003 or as recommended by the MGBC**. Wherever possible, these education and outreach efforts should be coordinated with existing efforts including, but not limited to, course work for architecture, engineering and landscape architecture students.

- Work with existing organizations such as Maryland Association of Counties and the Maryland Municipal League to develop model guidelines (e.g., ordinances or codes) that local jurisdictions could use to control light pollution. Assist local jurisdictions in using these guidelines to adopt local measures to reduce or stop the spread of light pollution **by July 1, 2005 as recommended by the MGBC**.

Appendix C lists outdoor lighting laws and regulations from other states. These can serve as templates for similar legislation at the State and local level in Maryland.

The Task Force served a very valuable purpose by bringing together the necessary interest groups to identify the issues related to light pollution in Maryland and to provide recommended actions to address those identified issues. Their hard work and commitment to this effort were extraordinary. A similar group working as a subcommittee of the Maryland Green Buildings Council, should review these recommendations and monitor their implementation. This would provide the necessary ongoing coordination, continuity and accountability sought by House Joint Resolution 14 sponsors.

HOUSE JOINT RESOLUTION 14

Unofficial Copy 2001 Regular Session
M1 (1lr0868)

ENROLLED RESOLUTION

-- Appropriations/Economic and Environmental Affairs --

Introduced by **Delegates Kopp, Barkley, Bronrott, Cadden, Clagett, Conroy, Cryor, D'Amato, Dypski, Goldwater, Grosfeld, Harrison, Howard, Hubbard, Hubers, Hurson, Love, Mandel, McIntosh, Menes, Morhaim, Petzold, and Shriver**

Read and Examined by Proofreaders:

_____
Proofreader.

_____
Proofreader.

Sealed with the Great Seal and presented to the Governor, for his approval this _____ day of _____ at _____ o'clock, _____M.

_____
Speaker.

RESOLUTION NO._____

A House Joint Resolution concerning

Task Force to Study Lighting Efficiency and Light Pollution in Maryland

FOR the purpose of establishing a Task Force to study the cost, extent, and consequences of inefficient public lighting and light pollution in the State and benefits of alternative improvements; providing for the membership and appointment of the Task Force; providing for the duties of the Task Force; requiring the Department of General Services to coordinate the professional and administrative support of the Task Force; requiring the Task Force to report to the General Assembly by a certain date; and generally relating to the Task Force to Study Lighting Efficiency and Light Pollution in Maryland.

WHEREAS, State and local governments and other public bodies, including the University System of Maryland, spend millions of dollars each year on lighting roads, buildings, and campuses and are also responsible for setting lighting standards and policies throughout the State; and

WHEREAS, Too often public funds are spent on lighting which is not optimally efficient, can waste both funds and energy, causes glare which does not enhance public safety and often causes light trespass and light pollution, and can threaten the very survival of amateur and professional astronomy, thereby reducing opportunity for children and others to appreciate the beauties of the night sky; and

WHEREAS, Good lighting policies save public funds while enhancing public safety; and

WHEREAS, Several agencies of State and local government have begun individually and separately to examine lighting policies and standards with the goal of enhancing efficiency, reducing cost, and reducing pollution, and would benefit from a joint examination of the problems and opportunities inherent in improved policies and practices and in exchange of information with experts such as representatives of the standards-setting Illuminating ~~Engineers Association~~ Engineering Society of North America; now, therefore, be it

RESOLVED BY THE GENERAL ASSEMBLY OF MARYLAND, That there is a Task Force to study the cost, extent, causes, and consequences of current public lighting standards and policies, light pollution, and the benefits of alternative policies in Maryland; and be it further

RESOLVED, That the Task Force shall be composed of ~~22~~ 23 members, as follows:

(1) Two members from the Senate of Maryland, designated by the President of the Senate;

(2) Two members from the House of Delegates, designated by the Speaker of the House;

(3) One representative from the Department of the Environment, designated by the Secretary;

(4) One representative from the Department of Natural Resources, designated by the Secretary;

(5) One representative from the Department of General Services, designated by the Secretary;

(6) One representative from the Maryland Energy Administration, designated by the Director;

(7) One representative from the University System of Maryland, designated by the Chancellor of the University;

(8) The Dean of the College of Computer, Mathematical and Physical Sciences of the University of Maryland, College Park, or the Dean's designee;

(9) Two representatives from the Maryland Department of Transportation, ~~including the Bicycle and Pedestrian Director and an official involved in the State Highway lighting program,~~ designated by the Secretary of Transportation;

(10) One representative from the Department of Business and Economic Development, designated by the Secretary;

(11) One representative from a County currently officially examining lighting policy and standards, designated by the Maryland Association of Counties;

(12) One representative of a municipality currently officially examining local lighting policy and standards, designated by the Maryland Municipal League;

(13) One representative from the Illuminating Engineering Society of North America, designated by the Executive Director of the Society;

(14) ~~Six~~ Seven members appointed by the Governor as follows:

(i) One representative of the professional astronomy community;

(ii) One representative of the amateur astronomy community;

(iii) One representative of an environmental group with expertise in the effects of artificial light on wildlife;

(iv) One representative of the public electric utility industry with a major role in road or exterior lighting;

(v) One representative of State or local law enforcement; ~~and~~

(vi) One representative from science educators at the secondary school level; and

(vii) One expert in human reactions to artificial light; and be it further

RESOLVED, That the Governor shall designate the Chairman of the Task Force; and be it further

RESOLVED, That the Department of General Services shall coordinate with other State agencies, including the University of Maryland, to provide professional and administrative support to the Task Force; and be it further

RESOLVED, That a member of the Task Force:

(1) May not receive compensation; but

(2) Is entitled to reimbursement for expenses under the Standard State Travel Regulations as provided in the State budget; and be it further

RESOLVED, That the Task Force shall:

(1) Estimate the potential fiscal and energy costs and savings, including the potential impact on the State budget and the budgets of county and municipal jurisdictions in the State, associated with the adoption of lighting practices that minimize inefficient lighting, light pollution, and energy waste while meeting important illumination and safety lighting requirements; and

(2) Study and document *the benefits of lighting to the public, including those who use Maryland's highways, airways, and other travelways, and* the consequences of light pollution in Maryland, including its impact on driving safety, general community safety, birds and other nocturnal fauna, astronomical research observation, the natural beauty of the night sky, and any other consequences the Task Force determines are appropriate for its attention;

(3) Survey and document the technology and standards currently available to minimize light pollution; and

(4) Prepare recommendations for public and private action to enhance lighting efficiency and minimize light pollution in Maryland, including, but not limited to, appropriate standards or policies for consideration by appropriate State agencies, counties, or municipal corporations in the State; and be it further

RESOLVED, That the Task Force shall issue a preliminary report of its findings and recommendations to the General Assembly, subject to § 2-1246 of the State Government Article, on or before October 15, 2001, and shall issue a final report of its findings and recommendations to the General Assembly on or before February 1, 2002; and be it further

RESOLVED, That a copy of this Resolution be forwarded by the Department of Legislative Services to the Honorable Parris N. Glendening, Governor of Maryland; the Honorable Thomas V. Mike Miller, Jr., President of the Senate of Maryland; and the Honorable Casper R. Taylor, Jr., Speaker of the House of Delegates.

Glossary

Area Lighting - all sources of outdoor lighting other than streetlights.

Ambient Light - lighting throughout an area that produces general illumination.

Cutoff-type luminaries - a luminaire light distribution where the candela per 1000 lamp lumens does not numerically exceed 25 (2.5 percent) at an angle of 90 above nadir, and 100 (10 percent) at a vertical angle of 80 above nadir.

Department - the Department of the Environment.

Direct Glare - is glare resulting from high luminances or insufficiently shielded light sources in the field of view or from reflecting areas of high luminance.

Emergency - any occurrence or set of circumstances involving actual or imminent physical trauma or property damage that demands immediate action.

Foot-candle, fc - is the illuminance on a surface one square foot in area on which there is a uniformly distributed flux of one lumen.

Foot-candle meter - an instrument, meeting IES Guide for Photometric Measurements, which is used for the measurement of lighting levels in a specified manner.

Full Cutoff - a luminaire light distribution where there is no light distribution at or above an angle of 90 degrees above nadir.

Glare - the sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility.

Horizontal Foot-candle - measurements taken with a foot-candle meter with the test cell positioned horizontal, 36 inches above grade.

IESNA - Illumination Engineering Society of North America.

Light Pollution - direct glare and light trespass caused by improperly designed outdoor lighting.

Light Pollution Standards - the goals for ambient light, the attainment and maintenance of which, in defined areas and under specific conditions, are necessary to protect the environment and general welfare.

Light Trespass - light that strays from its intended purpose and becomes a visual annoyance, even temporarily disabling.

Luminous efficacy - means the ratio of the total emitted lumens to power consumption. It is expressed in lumens per watt.

NEMA - National Electrical Manufacturers Association.

Pre-Curfew hours - from dusk up to 11 p.m. local time.

Post-Curfew hours - 11 p.m. to 7 a.m. local time.

Person - any individual, group of individuals, firm, partnership, voluntary association, or private, public, or municipal corporations, or political subdivision of the star or department, bureau, agency or instrument of federal, state or local government, responsible for the use of property.

Sky Glow - the added sky brightness caused by the scattering of electric light into the atmosphere, particularly from outdoor lighting in urban areas.

Source - any person or property, real or personal, contributing to light pollution.

Streetlight - lighting supplied from overhead or underground facilities on dedicated public streets and roads where required by City, Town, County or other Municipal or Public Agency, or by an incorporated association of local residents.

Zoning District - a general land use category, defined according to local subdivision, the activities and uses for which are generally uniform throughout the subdivision. For the purposes of this regulation, property which is not zoned "residential," "commercial," or "industrial," shall be classified according to use as follows:

Commercial - property used for buying and selling goods and services;

Industrial - property used for manufacturing and storing of goods:

Residential - property used for dwellings.

Outdoor Lighting Laws and Regulations in Other States

Arizona

Requirements:

Requires *all* outdoor light fixtures to be "fully" or "partially shielded." No new mercury vapor outdoor light fixtures can be installed and the use of mercury vapor light fixtures is prohibited after January 1, 2011. No replacement mercury vapor equipment, other than bulbs, can be sold in the state.

Exceptions:

Incandescent fixtures 150 watts or less and other lights 70 watts or less; streetlight fixtures if shielding is not available; fixtures not meeting the requirements, but which are extinguished between midnight and sunrise by an automatic shutoff device; mercury vapor lights erected prior to 1950; and navigational lighting systems at airports.

Other:

Provisions do not apply in counties, cities or towns with laws or regulations more stringent than these.

> "Fully shielded" fixtures are defined as fixtures that are "shielded in such a manner that light rays emitted by the fixture, either directly from the lamp or indirectly from the fixture, are projected below a horizontal plan running through the lowest point on the fixture where light is emitted."
>
> "Partially shielded" fixtures are defined as fixtures that are "shielded in such a manner that the bottom edge of the shield is below the plane of the center line of the lamp reducing light above the horizontal."

Colorado

Requirements:

Beginning July 1, 2002, any new outdoor lighting fixture with a rated output greater than 3,200 lumens, *installed* by or on behalf of the state, using state funds, must meet the following requirements:

- Must be a "full cutoff luminaire;"* must provide the minimum luminance adequate for the intended purpose, with consideration given to recognized standards including, but not limited to the recommended practices of IESNA;

- Full consideration is given to costs, energy conservation, glare reduction, minimization of light pollution and preservation of the natural night environment; and Where the purpose involved is the lighting of state highways, the Department of Transportation has determined that effective alternatives that do not require the use of artificial light cannot achieve the intended purpose.

Exceptions:

Preemption by federal law; temporary use in emergency situations; temporary use for nighttime work; special events (sporting events, illumination of monuments, historic structures, or flags), although efforts must be made to minimize up-light; the lighting "is used solely to enhance the aesthetic beauty of an object;" and there is a compelling safety interest that cannot be addressed using any other method.

Other:

The requirements are not binding for state prison facilities, including contract facilities.

> "Full cutoff luminaire" is defined as "a luminaire that allows no direct light emissions above a hrizontal plane through the luminaire's lowest light-emitting part."

Connecticut

Requirements:

No *state or municipal* funds can be used to install or replace a permanent outdoor luminaire for roadway lighting, and no public utility company may install or replace a permanent outdoor luminaire for roadway lighting where the costs of operating the lighting is paid for by municipal funds, unless:

The luminaire is designed to maximize energy conservation and minimize light pollution, glare and light trespass; the luminaire is equal to the minimum luminance adequate for the intended purpose; that luminaires used on state secondary and special service highways, with a rated output of more than 1,800 lumens, are *full cutoff*;* that luminaires used on municipal roads, with a rated output of more than 1,800 lumens, are full cutoff; that luminaires used on state primary highways, with a rated output of more than 1,800 lumens, are full cutoff, where the Commissioner of Transportation has determined that use of a full cutoff luminaire will not compromise the safety, increase costs of the lighting plan or lighting replacement for the highway, or violate federal law; the Commissioner of Transportation has determined that the purpose of lighting state highways cannot be achieved by reducing the speed limit or by installing reflectorized roadway markets, lines, warnings, informational signs or other means of passive or reflective lighting; and the chief elected officer of a municipality has determined that the purpose of lighting state highways cannot be achieved by reducing the speed limit or by installing reflectorized roadway markets, lines, warnings, informational signs or other means of passive or reflective lighting.

Exceptions:

The Commissioner of Transportation may waive these requirements if the Commissioner determines that a waiver is "necessary for the lighting application." In reviewing requests for waivers, the Commissioner must consider design safety, costs and other factors deemed appropriate by the Commissioner." The chief elected official of a municipality has essentially the same authority and discretion to waive the requirements. Public utility companies must request municipal waivers 30 days prior to installation or replacement of luminaire in question.

> "Full cutoff luminaire" is defined as a luminaire that allows no direct light emissions above a horizontal plane through the luminaire's lowest light-emitting part."

Maine

Requirements:

State funds cannot be used to *install or replace* any "permanent outdoor luminaire" unless:

For luminaires with rated output greater than 1,800 lumens, it is a "full cutoff luminaire"* and the luminaire does not exceed the minimum luminance recommended for the purpose involved by the IESNA or the federal Department of Transportation; and the Director of the Bureau of Public Improvements ensure that consideration is given to minimizing glare and light trespass.

Exceptions:

Preemption by federal law; and the Director of the Bureau of Public Improvements determines there is a compelling safety interest that cannot be addressed by any other method.

> "Full cutoff luminaire" is defined as "a luminaire that allows no direct light emissions above a horizontal plane through the luminaire's lowest light-emitting part."

New Mexico

Requirements:

All outdoor lighting fixtures, except low-pressure sodium lamps, must be "fully shielded."* Low-pressure sodium lamps must be "fully" or "partially shielded."

No new mercury vapor lights can be installed after July 1, 2000. No mercury vapor replacement equipment, other than lamps, can be sold after January 1, 2001. The use of mercury vapor lighting fixtures is prohibited after January 1, 2008.

The use of laser source light or any similar high intensity light for outdoor advertising or entertainment, when projected above the horizontal, is prohibited. The operating of searchlights for advertising purposes in prohibited between 10:00 p.m. and sunrise. The installation, sale,

offering for sale, lease or purchase of any outdoor lighting fixtures not meeting these requirements is prohibited.

Outdoor sign lights must be mounted on the top of the sign and must comply with all shielding requirements. Existing outdoor advertising structures must be brought into conformance of these requirements within three years of adoption.

No public or private outdoor recreational facility shall be illuminated after 11 p.m., except to conclude activities in progress before 11 p.m.

Exceptions:

Outdoor lights powered only by fossil fuels; outdoor lighting fixtures installed on residential structures with incandescent lamps rated less than 100 watts; decorative outdoor lighting fixtures with bulbs rated less than 25 watts, installed seasonally; outdoor fixtures used temporarily for emergency purposes by public safety or emergency medical personnel; outdoor lighting fixtures existing and legally installed prior to the effective date of these requirements, except that when the fixtures become inoperative they must be replaced with fixtures that comply with the requirements. Replacement of lamps is permitted, but no repair, replacement or structural alteration can occur without conforming to the requirements; and airport runway, taxiway, and navigational lighting systems.

All outdoor lighting fixtures must be turned off between 11 p.m. and sunrise, except:

- where business is conducted after 11 p.m.;
- for the illumination of advertising signs on the premises of a business, while it is open to the public, and
- lighting necessary for security purposes or to illuminate walkways or roadways.

In addition to other requirements, lighting fixtures must be shielded and/or directed in a manner that they illuminate only the owner's premises and do not spill over into neighboring areas.

Other:

Provisions do not apply in counties, cities, or towns with laws or regulations more stringent than these. Violations of these requirements are a misdemeanor and subject to fines of not less than $100 for each violation.

> "Fully shielded" means fixtures shielded such that light rays emitted by the fixture, either directly from the lamp or indirectly from the fixture, are completely restricted to region below an angle 15 degrees beneath the horizontal plane running through the lowest point on the fixture.
>
> "Partially shielded" means fixtures shielded or constructed so that no more than ten percent of the light rays emitted by the fixture, either directly from the lamp or indirectly from the fixture, project above the horizontal plan running through

the lowest point on the fixture.

Texas

Requirements:

Beginning September 1, 1999, any outdoor lighting fixture *installed, replaced, maintained, or operated* using state funds, must meet the following requirements:
If output rating greater than 1,800 lumens, be a "cutoff luminaire;"* be the minimum luminance adequate for the intended purpose, with consideration given to nationally recognized standards;
if for lighting a state highway, no "effective passive methods" cannot achieve the intended purpose; and full consideration must be given to "energy conservation, reducing glare, minimizing light pollution, and preserving the natural night environment."

Exceptions:

Preemption by federal law; temporary use in emergency situations; temporary use for nighttime work; special events (sporting events, illumination of monuments, historic structures, or flags), although efforts must be made to minimize up-light; the lighting "is used solely to enhance the aesthetic beauty of an object;" and there is a compelling safety interest that cannot be addressed using any other method.

"Cutoff luminaire" is defined as "a luminaire in which 2.5% or less of the lamp lumens are emitted above a horizontal plane through the luminaire's lowest part and 10% or less of the lamp lumens are emitted at a vertical angle 80 degrees above the luminaire's lowest point."

Survey Responses from County Governments and Larger Municipal Governments

The following are summaries of responses to questions posed to selected government officials in Maryland.

City of Annapolis

The City of Annapolis has outdoor lighting regulations concerning excessive lighting and light trespass. City ordinance section 21.64.200, "Design and Maintenance," states "... any lighting used to illuminate off-street parking areas shall be directed away from residential properties and public streets in such a way as to not create a nuisance. However, in no case shall the lighting exceed three foot-candles measured at the lot line." Also, Section 12.28.118, "Permit-Facilities Requirements," states that, "Lighting stations to be operated during the hours of darkness shall be provided with not less than two-tenths lumens of light per square foot measured on the pavement surface." The City receives infrequent complaints, but will respond to the site to measure light levels for compliance. The City works closely with BGE for maintenance and light level compliance. Currently, there are no plans to expand on the current outdoor lighting regulations.

City of Frederick

According to the Director of Planning, in practice the city has tried to insure parking lot lighting does not trespass onto adjacent properties or into the sky. The city does have "standards specification and designs" detailing specific street light structures that are acceptable. City officials respond to complaints but do not engage in proactive enforcement of light glare issues. During the site plan review process, the city often requires shadow/lighting plans to demonstrate the effectiveness of the light shields. This most often is required for commercial/industrial uses in close proximity to residential uses. It is not stipulated in current regulations, but is requested on an as-needed basis. Specific standards on when lighting plans are required are preferred but currently do not exist.

There are no specific efforts in the city to examine Frederick's outdoor lighting standards. They do plan on revising the city's zoning, subdivision and other land development regulations over the next two years into a unified development code; at that time, they may discuss lighting issues while addressing certain site plan issues. Consultant selection for the comprehensive plan and land development revision is to be completed in January with consultant work to begin shortly thereafter.

The director suggests that if the state wants to get involved in this matter, it should develop general development guidelines or model ordinance revisions for counties and municipalities to consider. The director does not recommend a state mandate.

City of Havre De Grace

In Havre De Grace, there are no regulations or ordinances currently in place and complaints are infrequent. BGE will occasionally respond to residential concerns; there have been instances where shields or cutoffs have been used to eliminate glare or light trespass. Currently, there are no plans to enact outdoor lighting regulations.

Anne Arundel County

There are no existing regulations or ordinances in Anne Arundel County. Occasionally, the county will receive a complaint concerning athletic field lighting glare or light trespass. Usually, no action is taken. The representative for the county expressed no significant concern for light pollution and no immediate plans to adopt outdoor lighting controls. As to whether the state should play a role in addressing light pollution issues within the county, no opinion was provided.

Calvert County

According to the Director of Planning and Zoning, county ordinances include a provision requiring outdoor lighting specifications for all site plans and prohibiting lights that produce glare or spillover onto surrounding properties. The county requires all outdoor lighting to shine down rather than horizontally. Although there are no specific requirements, the county does occasionally require builders to adjust plans to minimize ambient light. The director believes the there is a lack of awareness, and, therefore, feels that educating builders and the public about the issue and what can be done to minimize problems could have a positive impact. The Director said that there have been instances where residents have complained about existing and planned outdoor lighting. An example is an instance a few years ago on Solomon Island, when residents and businesses opposed county and state streetlight plans, resulting in plan revisions involving lower levels of light installed lower to the ground.

Frederick County

Frederick County currently has no ordinance or regulation addressing outdoor lighting. Outdoor lighting concerns, however, are raised on a regular basis by the public during plan review processes and after projects are constructed. While traffic, noise and other byproducts of development are regulated in numerous ways (state regulation, local regulation or a combination thereof), lighting remains unregulated. The Director of Planning believes that the public would welcome some form of local regulation but state regulation may appear to be "too much government." The director imagines developers would find lighting regulations unnecessary. Generally, the development community is willing to implement the recommendations of staff and the local Planning Commission when presented with reasonable alternatives.

The director said he would encourage the state to stay focused on issues of "greater importance and longer-lasting effect;" he added, that although lighting is an important issue, he believes it can be best regulated at the local level. Although no formal ordinance exists in Frederick County, a draft-zoning ordinance is being developed. The new ordinance contains strict, measurable standards for outdoor lighting. Until then, county staff will continue to work with developers and the Planning Commission to address lighting issues as they arise.

Garrett County

According to the Director of Planning, there are no countywide regulations or code requirements addressing outdoor lighting in Garrett County. (Garrett County is the only county in the state that does not have countywide zoning authority.) Although there are no regulations, certain conditions (shielding of lights, appropriate light intensity, etc.) sometimes are imposed on a case-by-case basis.

There have been complaints regarding specific commercial establishments – particularly convenience stores and service stations, with highly lit canopies. Businesses typically are responsive when contacted about complaints. An example is a recently constructed Wal Mart store. Area residents complained about the lighting surrounding the store and parking lot. The store responded by installing shields on parking lot lights. The Director said that local governing bodies would be unlikely to adopt controls unless local constituencies asked for controls or unless the state mandated controls. He believes the quality of the local response and the commitment to finding solutions could be enhanced by avoiding a mandate and providing local jurisdictions with model standards or guidelines that easily could be implemented at the local level.

Montgomery County

Montgomery County addresses light trespass in a limited fashion in zoning ordinances by requiring shielding of fixtures and by prohibiting intrusion onto residential property or adverse effects on roadways. These requirements deal only with certain golf course and parking lot lighting. Incidences of light trespass occasionally are referred to county government officials as complaints from residents. These are addressed on an as-needed basis and no formal procedure is in place at this time. At present, the county has no overall ordinance or regulation regarding light pollution. Some lighting efficiency and shielding requirements are included in the Energy Design Guidelines used for all new construction and major renovations of county government facilities.

Montgomery County is interested in statewide legislation that would set some baseline requirements for all jurisdictions in Maryland that could be amended or strengthened by individual jurisdictions. A statewide code would simplify requirements and eliminate problems arising from variations in requirements from one county or municipality to another. At a minimum, a statewide code could address lighting that no local jurisdiction has authority over, such as state highways. In the long term, regional or national requirements would be beneficial. Should the Governor's Light Pollution Task Force continue to function, the issue of regional cooperation could be addressed.

Prince George's County

There are no existing regulations or ordinances in Prince Georges County; however, the county is considering establishing a lighting requirement or standard for historic and scenic roadways. In urban areas, the county receives occasional complaints regarding the county-operated street lighting systems and responds to each concern on an individual basis. The County does not dictate or respond to issues regarding private or commercial lighting concerns. The official said

that the complaints are infrequent and that there are no plans to develop further regulation for county-maintained lighting systems.

St. Mary's County

St. Mary's County has a lighting ordinance that limits installations to one half foot-candle at a property/zone/district boundary. The county is in the midst of a comprehensive code update but lighting is not being considered as a single issue. Outdoor lighting issues have been raised by the public, the Director of Planning and Zoning and the County Commissioners. Light trespass and excessive brightness were two issues mentioned. The Director believes that outdoor lighting controls are needed—especially for public safety. Poorly lit signs and over lit signs are an issue due to poorly designed and aimed installations.

There has been a debate about internally lit signage. They have had internally lit signs installed in rural, very low ambient light level areas that were too bright even though they were within their ordnance specification of .5FC on the ground in the vicinity of the sign. The Director believes a code must be enacted to distinguish between urban and rural light levels. The Director also thinks there would be no obstacle to adopting outdoor lighting codes. However, he thinks the state should offer a model ordinance or code only and strongly believes the final position should be local governments' decision. Presently, St. Mary's County uses the National Planners Advisory Service from the American Planning Service as a resource when considering writing codes and ordinances.

Washington County

The Director of Planning reported that although there are no specific standards or ordinance requirements, the county does typically require new site plans submitted for approval to include an outdoor lighting plan. The lighting plan must include information about the type and location of fixtures. They are not concerned about lighting intensity, rather, they are interested in ensuring that light is shielded or deflected to avoid trespass or glare – especially on nearby streets and highways. There are no outdoor lighting guidelines or standards to give builders or developers before a site plan is prepared. The county does receive complaints from time to time, which they investigate. If a nuisance is present, they will talk with the property owner and try to resolve the conflict. The director expressed a need to provide better information to builders, developers and planning officials about lighting issues and how they can avoid problems. He stressed, however, that flexibility is needed and that too specific standards can cause problems. (He noted an ongoing problem in Sharpsburg, MD, involving a bar with a very brightly lit sign.)

Additional Survey Responses from Maryland Municipalities

Question	Gaithersburg	Greensboro	Bowie	Somerset
Does your municipality have an existing ordinance or regulation addressing outdoor lighting?	Not yet, there is a draft version used by Planning and Code Adm.	Only with subdivision planning.	The City has provisions in its Development Review Guidelines.	No
Have outdoor lighting issues been or concerns (glare, excessive lighting, trespass, sky glow) been raised by the public?	Yes	Issues with ball fields.	Yes, a few residents.	Commercial near residential.
Do you believe outdoor lighting controls are needed, why?	The City believes some controls are needed, but not too restrictive placing too high a cost on citizens.	Controls are needed to reduce intense lighting.	Gaining clear public agreement.	No, not a priority issue.
Do you see major obstacles to adopting outdoor lighting controls? If yes, what are the obstacles?	Public perception is a problem.	N o	State help with funding.	Not necessary.
What role do you think the State of MD can play in addressing this issue? How can the State support their efforts?	The state can provide guidance and support.	State can develop ordinance.		None.

Question	Berlin, MD	Cambridge	District Heights	Town of Queen Anne
Does your municipality have an existing ordinance or regulation addressing outdoor lighting?	Not a lighting specific ordinance. Street lighting is part of the planning development process.	Yes.	No.	No.
Have outdoor lighting issues been or concerns (glare, excessive lighting, trespass, sky glow) been raised by the public?	Mainly at the planning and zoning meetings, and occasionally at Mayor and Council meetings, when there are plans for business next to residential. Generally public does not like sodium lamps.	No.	No.	No.
Do you believe outdoor lighting controls are needed, why?	Yes, mainly to ensure public safety.	No, leave to local community.	No. 95% residential. We need more lighting.	No - Not in our town.
Do you see major obstacles to adopting outdoor lighting controls? If yes, what are the obstacles?	State can put out general guidelines. If the State mandates requirements in the name of public safety, then it must provide some sort of funding.	More unnecessary regulations for overburdened Public Works Dept.	Yes, funding.	No.
What role do you think the State of MD can play and should play in addressing this issue? How can the State support their efforts?	See above.	None.	F unding.	None

Question	Bladensburg	Centreville	Myersville	Barnesville
Does your municipality have an existing ordinance or regulation addressing outdoor lighting?	No.	Yes.	No.	No.
Have outdoor lighting issues been or concerns (glare, excessive lighting, trespass, sky glow) been raised by the public?	A few cases.	Yes.	Ye s.	Yes. Concerns for more regulation. People don't understand, care, or just like light.
Do you believe outdoor lighting controls are needed, why?	No	Yes, public protection	No	Yes. Public wants it.
Do you see major obstacles to adopting outdoor lighting controls? If yes, what are the obstacles?	Don't need.	Meeting the needs of developers and residents	Public Outcry	Yes. Concerns for more regulation. People don't understand, care, or just like light.
What role do you think the State of MD can play and should play in addressing this issue? How can the State support their efforts?	None.	Standardize Counties and municipalities	Should be a local issue	State could mandate light covers and proper shielding.

Question	Charlestown	Hancock	Union Bridge	Berwyn Heights
Does your municipality have an existing ordinance or regulation addressing outdoor lighting?	No.	No.	No.	No.
Have outdoor lighting issues been or concerns (glare, excessive lighting, trespass, sky glow) been raised by the public?	No.	N o.	No issues.	No.
Do you believe outdoor lighting controls are needed, why?	No, mostly State highway issue.	No.	No.	Possibly.
Do you see major obstacles to adopting outdoor lighting controls? If yes, what are the obstacles?	Too many ordinances.	No	No reason.	Cost of implementation and enforcement.
What role do you think the State of MD can play and should play in addressing this issue? How can the State support their efforts?	None.	N one	None.	Proactively promote.

Appendix F

Existing Exterior Lighting Data, DGS Operated Facilities

Exterior Lighting Consumption / Costs Analysis for DGS Facilities

Facilities	**Total KWH Per Year**	**Total Costs Per Year**	**Total KWH / Year - Parking**	**Total Costs / Year - Parking**
Annapolis Complex	642,221.88	20,048.69	267,727.5	8,113.78
Baltimore Complex	176,426.4	11,807.00	80,592.0	5,251.26
Inner Harbor Complex	147,956.4	9,596.96	38,828.7	2,391.31
Multi Service Centers	326,797.28	13,741.66	179,886.6	7,166.61
Totals	**1,293,401.96**	**$ 55,194.31**	**597,034.8**	**$ 22,972.96**
% of total attributable to exterior parking areas	----------	----------	**46.16 %**	----------

Exterior Lighting Consumption / Costs Analysis, DGS Facilities
Annapolis Complex

Facility	Total KWH Per Year	Total Costs Per Year	Total KWH / Year - Parking	Total Costs / Year – Parking
State House	35,613.78	1,089.00	N/A	N/A
Jeffrey Building	3,504.0	106.99	N/A (Note 1)	N/A
Shaw House	3,372.6	102.95	N/A	N/A
Government House	53,874.0	1,604.69	N/A (Note 1)	N/A
Lawyers' Mall	9,898.8	302.40	N/A	N/A
Leg. Services Bldg.	14,059.8	850.68	N/A (Note 1)	N/A
Miller Senate Bldg.	4,721.64	144.22	N/A (Note 1)	N/A
House Office Bldg.	15,242.4	465.46	N/A (Note 1)	N/A
Data Center	5,256.0	160.48	N/A	N/A
Revenue Admin.	36,879.6	1,125.97	N/A	N/A
Central Services	6,351.0	190.92	N/A (Note 1)	N/A
B & C Lots	40,296.0	1,230.24	40,296.0	1,230.24
Street Lights	76,825.2	2,395.55	N/A	N/A
Treasury Building	9,022.8	275.48	N/A	N/A
Attman Glazer	16,587.06	506.51	5,365.5	163.81
State Police Brks.	39,078.36	1,193.17	33,288.00	1,016.29
Courts of Appeals	33,314.28	967.19	29,346.0	895.94
Archives Building	32,030.94	978.08	24,528.0	748.84
Tawes Building	76,838.34	2,345.97	40,296.0	1,230.27
District Court	32,850.0	1,123.28	19,272.0	588.38
Crownsville PRC	78,910.08	2,349.22	61,320.0	1,812.10
Childcare Center	17,695.2	540.24	14,016.0	427.91
Totals	**642,221.88**	**20,048.69**	**267,727.5**	**8113.78**

Note 1. Parking area inside, or considered primarily pedestrian walkway - not general parking area.

Note 2. All figures based on average operating time of 12 hours per night, 7 nights per week, throughout the year.

Exterior Lighting Consumption / Costs Analysis, DGS Facilities
Baltimore Complex

Facility	Total KWH Per Year	Total Costs Per Year	Total KWH / Year - Parking	Total Costs / Year - Parking
201 W. Preston St.	72,620.4	5,172.61	N/A (Note 1)	N/A
300 W. Preston St.	22,119.0	1,315.24	8,760.0	543.12
301 W. Preston St.	9,855.0	611.01	N/A (Note 1)	N/A
2100 Guilford Ave	36,792.0	2,535.16	36,792.0	2,535.16
Lots B,C,E & F	35,040.0	2,172.98	35,040.0	2,172.98
Totals	**176,426.4**	**11,807.00**	**80,592.0**	**5,251.26**

Note 1. Parking area inside, or considered primarily pedestrian walkway - not general parking area.

Note 2. All figures based on average operating time of 12 hours per night, 7 nights per week, throughout the year.

Exterior Lighting Consumption / Costs Analysis, DGS Facilities
Inner Harbor Complex

Facility	Total KWH Per Year	Total Costs Per Year	Total KWH / Year - Parking	Total Costs / Year - Parking
Schaefer Tower	57,772.2	4,344.00	N/A (Note 1)	N/A
Surplus Property	29,893.5	2,241.00	10,512.0	788.00
Jessup Complex	33,178.5	2,489.00	20,038.5	1,503.00
Saratoga Center	17,322.9	346.33	5,606.4	37.64
500 N. Hilton St.	9,789.3	176.63	2,671.8	62.67
Totals	**147,956.4**	**9596.96**	**38,828.7**	**2,391.31**

Note 1. Parking area inside, or considered primarily pedestrian walkway - not general parking area.

Note 2. All figures based on average operating time of 12 hours per night, 7 nights per week, throughout the year. (These notes apply to both cost analyses on this page.)

Exterior Lighting Consumption / Costs Analysis, DGS Facilities
Multi-Service Centers

Facility	Total KWH Per Year	Total Costs Per Year	Total KWH / Year - Parking	Total Costs / Year - Parking
Arbutus MSC	41,566.2	669.30	21,900.0	352.60
Centreville MSC	25,272.6	2,223.82	10,818.6	952.00
Salisbury MSC	32,521.5	1,732.52	22,995.0	1,224.90
Borgerding MSC	29,565.0	1,273.61	26,280.0	1,140.55
Bel Air MSC	20,476.5	745.06	12,045.0	434.77
Hagerstown MSC	9,373.2	346.25	2,190.0	80.90
Ellicott City MSC	74,845.44	1,197.10	45,552.0	728.30
Glen Burnie MSC	24,230.16	1,908.54	11,826.0	931.50
Elkton MSC	16,775.4	978.56	6,570.00	383.25
Denton MSC	33,616.5	1,905.00	10,512.0	575.00
Essex MSC	10,906.2	430.02	7884.0	310.56
Shillman Bldg.	7,648.58	331.88	1314.0	52.28
Totals	**326,797.28**	**13,741.66**	**179,886.6**	**7,166.61**

Exterior Lighting / Consumption by Lamp Types,
DGS Facilities, Summary

Figures indicate kilowatt hours

Facilities	Incandescent	Merc. Vapor	Met. Halide	Sodium	Fluorescent
Annapolis Complex	276,312.3	241,009.5	0	111,339.6	13,561.3
Baltimore Complex	84,227.4	31,755.0	0	60,444.0	0
Inner Harbor Complex	23,936.7	10,950.0	69,532.5	40,909.2	2,628.0
Multi Service Centers	5,097.23	142,021.5	60,181.2	102,229.2	17,268.15
Totals	**389,573.63**	**425,736.0**	**129,713.7**	**314,922.0**	**33,457.45**
Percentage	**30.1 %**	**32.9 %**	**10.0 %**	**24.4 %**	**2.6 %**

Exterior Lighting / Consumption by Lamp Types, DGS Facilities
Annapolis Complex

Figures indicate kilowatt hours

Facility	Incand.	Mer. Vapor	Met. Halide	Sodium	Fluorescent
State House	6,460.5	17,520.0	0	9,811.2	1,822.08
Jeffrey Building	3,504.0	0	0	0	0
Shaw House	3,372.6	0	0	0	0
Government House	45,771.0	7,665.0	0	438.0	0
Lawyers' Mall	0	7,446.0	0	2,452.8	0
Leg. Services Bldg	12,526.8	0	0	1,533.0	0
Miller Senate Bldg	1,314.0	0	0	3,066.0	341.64
House Office Bldg	15,242.4	0	0	0	0
Data Center	5,256.0	0	0	0	0
Revenue Admin.	35,040.0	0	0	0	1,839.6
Central Services	4,818.0	1,533.0	0	0	0
B & C Lots	0	40,296.0	0	0	0
Street Lights	76,212.0	0	0	613.2	0
Treasury Building	8,409.6	0	0	613.2	0
Attman Glazer	10,380.6	5,365.5	0	0	840.96
State Police Brks.	3,591.6	34,821.0	0	0	665.76
Courts of Appeal	0	29,346.0	0	0	3,968.28
Archives Building	3,679.2	26,827.5	0	0	1,524.24
Tawes Building	3,942.0	70,189.5	0	1,971.0	735.84
District Court	32,850.0	0	0	0	0
Crownsville PRC	3,942.0	0	0	73,146.0	1,822.08
Childcare Center	0	0	0	17,695.2	0
Totals	**276,312.3**	**241,009.5**	**0**	**111,339.6**	**13,560.48**

Exterior Lighting / Consumption by Lamp Types, DGS Facilities
Baltimore Complex

Figures indicate kilowatt hours

Facility	Incand.	Mer. Vapor	Met. Halide	Sodium	Fluorescent
201 W. Preston St.	52,691.4	16,425.0	0	3,504.0	0
300 W. Preston St.	1,971.0	0	0	20,148.0	0
301 W. Preston St.	3,285.0	6,570.0	0	0	0
2100 Guilford Ave	26,280.0	8,760.0	0	1,752.0	0
Lots B,C,E & F	0	0	0	35,040.0	0
Totals	**84,227.4**	**31,755.0**	**0**	**60,444.0**	**0**

Exterior Lighting / Consumption by Lamp Types, DGS Facilities
Inner Harbor Complex

Figures indicate kilowatt-hours

Facility	Incand.	Mer. Vapor	Met. Halide	Sodium	Fluorescent
Schaefer Tower	1,051.2	0	56,721.0	0	0
Surplus Property	7,884.0	10,512.0	0	11,497.5	0
Jessup Complex	6,570.0	0	0	23,980.5	2,628.0
Saratoga Center	1,314.0	438.0	12,811.5	2,759.4	0
500 N. Hilton St.	7,117.5	0	0	2,671.8	0
Totals	**23,936.7**	**10,950.0**	**69,532.5**	**40,909.2**	**2,628.0**

Exterior Lighting / Consumption by Lamp Types, DGS Facilities

Multi-Service Centers

Figures indicate kilowatt-hours

Facility	**Incand.**	**Mer. Vapor**	**Met. Halide**	**Sodium**	**Fluorescent**
Arbutus MSC	0	31,755.0	0	1,226.4	8,584.8
Centreville MSC	0	14,454.0	0	10,818.6	0
Salisbury MSC	0	0	32,521.5	0	0
Borger ding MSC	0	0	0	29,565.0	0
Bel Air MSC	0	0	5,584.5	14,892.0	0
Hagerstown MSC	0	0	5,431.2	3,942.0	0
Ellicott City MSC	0	73,584.0	0	0	1,261.44
Glen Burnie MSC	0	0	6,132.0	11,826.0	6,272.16
Elkton MSC	1,314.0	0	0	15,461.4	0
Denton MSC	1,314.0	20,914.5	10,512.0	876.0	0
Essex MSC	0	1,314.0	0	8,803.8	788.4
Shillman Bldg.	2,469.23	0	0	4,818.0	361.35
Totals	**5,097.23**	**142,021.5**	**60,181.2**	**102,229.2**	**17,268.15**

Benefits of Lighting

Introduction:

The objective of any lighting system is to maximize visibility in performing a given task, while minimizing the amount of energy and associated costs used in producing the light. It is also desirable to minimize the amount of light pollution that is produced by a given system. Light should not be cast into unintended places such as onto adjacent property or skyward. This light is not being used to accomplish the task of seeing, and therefore is inefficient. A lighting system should produce no more lighting than is necessary for a given task, and do so using luminaires that place the light only where it is needed. This approach can help to minimize costs and reduce light pollution.

There are many good reasons for providing lighting. It is a necessity for performing visual tasks indoors, day or night. There also are many reasons for outdoor lighting, chief among which is to provide motorist, pedestrian and general community safety and security, encouraging the use of public spaces at night. According to a 1996 National Institute of Justice Research Brief, *Crime Prevention through Environmental Design* (CPTED), "The most important CPTED security feature is lighting. Lighting should meet standards of the Illuminating Engineering Society of North America" (IESNA). It also stated that, "The most important CPTED security feature a city can mandate is lighting." There is even the potential for liability on the part of businesses or communities if someone is victimized or involved in an accident where it can be alleged that the lighting in the area was insufficient. Because of the importance of adequate lighting to the public's real and perceived safety, no individual or group should attempt to discourage the use of lighting by any other group, particularly if it is in the interest of safety and security. We all should, on the other hand, encourage the use of responsible lighting design practice for every lighting system installed. This can be achieved by setting guidelines based on established national standards and by enforcing the guidelines through the plans review and permitting procedures of a local jurisdiction. The goal is to provide enough lighting to perform the visual task at hand, while controlling the distribution of the light so that light pollution is minimized and visibility is maximized.

The Illuminating Engineering Society of North America defines recommended minimum lighting levels sufficient for safety and security for any conceivable application and associated ratios that define how evenly lit (uniform) an application should be. While it is necessary to allow for system maintenance considerations, these minimum recommended levels should not be exceeded by a significant amount. Over lighting has become a common malpractice in lighting design, conforming to the "more is better" philosophy. Over lighting wastes energy, increases glare and contributes to sky glow. For lower levels of lighting to remain effective, however, they must be applied across the board. Neighboring systems cannot be in competition with each other in attempts to produce the highest lighting levels. This requires both public and private cooperation in lighting system design. More light does not mean better visibility. In fact, higher levels in a poorly designed system can make visibility poor. Use of IESNA standards

and constantly improving technology permits the reduction of light pollution without conflicting with public safety needs.

Lighting equipment should be chosen based on its ability to direct the light where it needs to go and to prevent the light from going where it is not wanted. Cutoff luminaires do not allow any light to be distributed above the horizontal axis of the luminaire. This significantly reduces sky glow and can aid in reducing light trespass on adjacent property. The use of cutoff type luminaires also reduces the glare component of a given lighting system and increases visibility. The use of cutoff type luminaires should be strongly encouraged where appropriate, and at the same time, the indiscriminate aiming of luminaires skyward should be strongly discouraged. It should be noted that there are limited applications where it is desirable to distribute light above the horizontal axis. No matter what the application might be, there usually is a responsible way to design the lighting so that lighting pollution is minimized and visibility is maximized.

Driving Safety:

Driving safety may be augmented by providing good roadway lighting systems. The driver needs to be able to see the features of the roadway, fixed obstacles, other moving vehicles and pedestrian traffic. As the complexity of roadway movements, number of entrances, number of other vehicles, number of pedestrians and ambient lighting levels increase, the lighting system also must increase in output and uniformity. Recommendations for levels and uniformity are given by the IESNA for various roadway types under various conditions. These recommendations are given as minimum levels, but there is seldom a reason to increase these levels above their recommended minimums. One such reason would be if businesses adjacent to the roadway were over lit. This is why it is important to discourage over lighting across the board, both publicly and privately. One of the most detrimental aspects of a roadway lighting system is glare. Glare can be minimized by using cutoff luminaires and by not over lighting.

Pedestrian Safety:

Pedestrians must be able to see the features of the path on which they are walking. They also must be able to be seen by motorists. In addition, illumination in the vertical plane aids in the identification of would-be assailants, and in doing so, it is widely believed that the assailant is deterred. Conclusive data linking lighting to decreases in crime is difficult to obtain. There is little doubt, however, that lighting produces a perceived sense of safety to the pedestrian. The IESNA also publishes recommended minimum levels for walkways and bikeways. Adherence to these recommendations should be encouraged. When a pedestrian lighting system is installed adjacent to a roadway, the impact on the roadway must be determined. These systems cannot be designed independently of each other. Again, appropriate cutoff luminaires should be specified to minimize glare, sky glow, and other forms of light pollution, such as trespass while adequately lighting the scene.

General Community Safety:

Businesses and residences provide night lighting at building perimeters and throughout their property in order to discourage theft, vandalism or other types of crimes. In addition, for

purposes of marketing and increasing mercantile and recreational activity, the use of lighting should be encouraged, but in responsible ways. Over lighting is perhaps most common among private business owners. This practice should be discouraged by local jurisdictions and variations from the established maximum or minimum recommended lighting levels should be justified through the local permitting process or other public forum. During non-operating hours, non-essential lighting should be turned off. Curfews should be considered for lighting systems that have no reason to be on in the early morning hours. For example, tennis courts and ball field lighting systems should be turned off when not in use. Cutoff type luminaires should be used wherever possible and aesthetic lighting should be designed with regard to where the light might be going unintentionally.

Light Pollution

Misdirected or misapplied outdoor lighting is a concern for aesthetic, environmental and energy management reasons. A substantive amount of sky glow and light trespass can be attributed to roadway lighting. As society has increased the applications of lighting to improve roadway safety, building security and personal safety, concern about the resulting adverse environmental effects has arisen. Listed below is a brief discussion of the three components to light pollution: sky glow, light trespass and glare.

Sky Glow

Sky glow is the term used to describe the added sky brightness caused by the scattering of light into the atmosphere, particularly from outdoor lighting in urban areas. Sky glow is composed of both a man-made component and a natural component. The man-made component of sky glow is what "light pollution" properly denotes. It is the artificial glow that hangs over populated areas, washing out the view of the night sky to varying degrees. On the other hand, the natural sky has a certain minimum surface brightness even in the most pristine, unspoiled environment. This natural component of sky glow has four sources: faint air glow in the upper atmosphere (a permanent, low-grade aurora), sunlight reflected off interplanetary dust (zodiacal light), starlight scattered in the atmosphere and background light from faint, unresolved stars and nebulosity. Airglow peaks around the maximum of the 11-year sunspot cycle; the other sources vary with the hour of night and the seasons. But their combined average is well known.

The effects of man-made sky glow can be tremendous. For example, a typical suburban sky today is about 5 to 10 times brighter at the zenith than the natural sky. In city centers the zenith may be 25 or 50 times brighter than the natural background. Sky glow from man-made sources is directly proportional to the installed lumens and reflectivity of the surface. For example, a bituminous concrete highway, due to its black surface color, absorbs more light than a concrete highway and hence contributes less to sky glow. A particular concern to astronomers is light directed above the horizontal plane. Luminaires with cutoff photo metrics can significantly reduce this component of sky glow.

In the last two generations, sky glow has spread from a localized problem in Maryland's larger urban centers to our suburban communities. This is a concern to amateur astronomers[1] because if this phenomenon is left unchecked, it will render conventional back yard equipment obsolete for viewing stars.

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[1] Professional observatories are located predominately in the southwest region of the United States due to prevailing favorable climatic conditions.

Light Trespass

Light that strays from its intended purpose and becomes a visual annoyance is known as light trespass. Most complaints about light trespass come from people upset by stray light entering their windows or intruding upon their property. In most cases, the problem of light trespass can be traced to inappropriate lighting design, improper aiming, or inappropriate maintenance.

Light trespass problems usually can be addressed by using a different type of luminaire, shielding or in worst cases, relocating the offending luminaires. Light trespass is something that easily is measured; limits on it can be enforced by specifying measurable limits for light trespass in terms of luminance at a property line. In areas with intrinsically dark fields of view, light source limitations may also be required to remedy complaints about light trespass.

Glare

A severe form of light trespass involves glare. "Glare" is defined by the Illumination Engineering Society of North America as "the sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility." Simply stated, glare is light that beams directly into your eye from a bright source (e.g., the sun, the moon, or an outdoor lighting fixture). Glare is related closely to light trespass. By controlling light trespass, often times issues associated with glare also are addressed. Other factors that contribute to glare include the size, position, and luminance of the source, ambient light levels, extreme brightness contrasts and differences in human eye sensitivity.

Impacts of Light Pollution

Night Driving Hazards

Many types of outdoor lighting designed for advertising, security and visibility are actually wasteful, invasive, and a source of disabling glares. Public hazards have been created by the use of glaring, high-wattage floodlighting along roadways and business parking lots that shine directly in the driver's line of sight. Public safety also is being compromised by businesses competing with light levels to attract business. The eye's inability to adjust quickly to drastic changes from light to dark leaves a driver temporarily blinded when exiting an over-lit business area at night. It is rather commonplace to see businesses using three to six times the recognized lighting industry recommendations for site lighting (IESNA).

Effects on Observations of the Night Sky

There are few ground-based astronomical observatories in Maryland. Most professional astronomy efforts from the ground are now accomplished in extreme western states where the combination of more favorable weather and fewer population centers afford a more pristine view of the sky. However, amateur astronomy is alive and well in Maryland. However, as time passes, most serious amateurs will have to travel greater and greater distances to view the heavens from a suitable dark site. More troubling is the fact that many Maryland children today have already lost much of the starry night sky behind the glow of wasted light, limiting their imaginations to the manmade boundaries around them. Thus, slowly but surely, public interest in viewing the night sky will only be satisfied by visiting a planetarium, which is a poor substitute for the experience of seeing the natural night sky overhead. Presently, in the city of Baltimore on any given night, only 20 of the brightest stars typically are visible among the 6,000 stars that could be visible from a suitably dark site. Most children in Maryland cities and suburbs have never seen the Milky Way. This condition has arisen in approximately the last fifty years.

Effects on Daily and Seasonal Cycles of Animals and Plants

Light pollution confuses the instinctive daily and seasonal cycles of animals and plants. The specific impacts of light pollution on flora and fauna are beginning to be documented. Based on current research, it is reasonable to expect that light pollution adversely affect many organisms. Light pollution's ability to disrupt the natural behavior patterns of flora and fauna could ultimately have profound negative effects on the ecological system.

Effects on Birds and Bird Migration

While some species of North American birds do not migrate at all, the vast majority of them do migrate, southward in the fall and northward to breeding grounds in the spring. Of these birds,

some are diurnal migrants, but most have evolved to take advantage of the protections that nighttime - darkness and relative coolness - offers them. Nocturnal migrants navigate using a combination of cues. An especially important one is celestial navigation, the recognition of star patterns sufficient to maintain their orientation in the proper direction. Light pollution and lights on tall buildings can confuse birds, causing collisions with the buildings. The height at which migrant birds fly is a critical factor affecting collisions. It is now known that most migration occurs at rather low elevations, less than 1000 feet above ground level, with a large fraction occurring below 500 feet. The density of migrants is greatest at the lowest level, decreasing exponentially with height.

When nocturnal migrants encounter tall, bright buildings at or above birds' horizon, one of two things may occur. They may perceive the building as "dawn" and drop down to land, or their celestial navigation system may become overwhelmed. In the case of the latter, the birds become confused, causing them to strike the buildings or fly aimlessly among them until expiring from exhaustion. The problem is the direct beam or glare from the light source is misdirected and causes confusion. The toll on migrants is large; an urban center such as Toronto produces at least 2,000 fatal strikes per year. Studies have concluded that tall, lighted buildings are directly related to bird collisions. However, when a previously illuminated building is darkened, collisions against it cease even when neighboring buildings are still bright. Smaller buildings, generally 25 stories or fewer, do not present a collision threat. Scientists believe this is because they stand well below birds' horizon and they do not perceive the bright buildings to be a celestial object.

Ever since the advent of tall (>500' or so) radio towers, there have been many reports of bird kills caused by collisions. The numbers can reach up to 10,000 in a single night. But these reports are mostly haphazard; very few systematic studies have been made. Studies have shown that towers are much more lethal, structure for structure, than urban skyscrapers. At the two or three sites where regular monitoring has been conducted over a long span of time, an average mortality of 1,500 birds per year per tower was typical. The cause is aircraft warning lights that all such towers over 200' are required to carry. The lights are even more star-like than the lights from office buildings and often are carried at a height of 1000' - well into the height distribution of migrating birds. Not only do birds collide with a tower itself, but they also fly into the much larger cross-section of guy wires supporting the structure.

These studies suggest that towers exceeding a height between 300'-500' are hazardous to migrants. The lights on lower towers are perhaps perceived as non-stellar. With the number of towers exceeding 1000' soon to explode with the spread of digital communications media, the potential for significantly increased avian mortality due to collisions is very great.

One solution may be the use of strobe lights. There is some evidence that strobe lights, which appear less "natural" than slowly "winking" lights, may be less confusing to birds and so may offer a remedy, especially if the flash cycle is the full 3 seconds allowed by FAA regulations; but no hard evidence is yet available.

Suggestions to Reduce Migratory Bird Impact

The total nighttime luminous flux emanating from buildings taller than 25-30 stories should be greatly reduced. Wartime blackout experience shows that this can be achieved by turning out lights that are not needed, and covering windows in rooms where they are. The use of decorative lights atop buildings should be eliminated. The decorative spot lighting of tall buildings should be well considered and designed. Illuminated landmarks and monuments, such as the U.S. Capitol, usually are not a problem in this regard because they are typically not tall enough to pose a hazard to migrants.

The hazard communications towers pose is more difficult to address. Lights on these are necessary to indicate the locations of the towers. First, the true extent of the damage they inflict should be determined by a careful monitoring of avian mortality under controlled conditions. A state agency, at an appropriate time, such as the Maryland Department of Natural Resources, should conduct such a study under a variety of tower heights, surrounding topographies, light colors and flash frequencies. A requirement that such studies be permitted at tower sites should be made a condition of construction licenses for towers exceeding 200'.

Impact on Diurnal Cycles of Plankton

A study in the *Proceedings of the International Association of Theoretical and Applied Limnology* found that "the movement of Daphnia was significantly greater in both amplitude and magnitude in the black enclosures than in control enclosures within the lake." Because zooplankton responded more normally in the black enclosures simulating a dark night, the researchers concluded that light pollution, as seen in the control enclosures, was the cause of the decreased migration. This is important because reduction in surface migration leads to increased amounts of surface algae left unconsumed by the zooplankton, which in turn could lead to algal blooms and poor water quality. Given that the State of Maryland has placed significant emphasis in protecting the Chesapeake Bay and its waterways, as demonstrated by the Chesapeake 2000 Agreement, it is important to consider such effects of light pollution.

Impact on Sea Turtles

The effects of light pollution on sea turtles have been well documented. Sea turtles and hatchlings rely on the moon to direct them from the beach, back to the water. Sea turtles mistake artificial light sources for the moon and often never make it back to the water. This is becoming more of an issue as beachfront development trends continue. The three most common sea turtles found in the Chesapeake Bay are the Leatherback, Loggerhead and Kemp's Ridley. Light pollution's effect on sea turtles is not a large problem in Maryland because sea turtles rarely spawn north of Virginia, however as recently as 1999 there was a nest sighting in Maryland. Sea turtle nests have been found in Ocean City, MD, where significant light from roads and businesses exists. Light pollution's potential effects on sea turtles should be addressed because all three turtles mentioned above are protected by The Endangered Species Act of 1973.

Quality of Life

It is difficult to quantify the cost of lighting inefficiency on quality of life. We know light pollution intrudes on a person's right to privacy. It also can be considered an abuse of rights when artificial illumination is projected or spilled onto someone else's property. Light pollution also can negatively impact a human's ability to get a good sound night's sleep when artificial illumination coming from poorly designed light fixtures shines glare into windows at night. Too much artificially generated light at night can have adverse affects on our health by disrupting natural hormone production that our bodies require. Studies have shown that the presence of light during sleep affects the body's ability to produce megaton, a hormone that regulates the body's circadian rhythm. While there are few conclusive studies regarding the effect reduced levels of melatonin have on the human body, initial studies indicate that melatonin levels may be related to cellular immunity which is our bodies' way of fighting infection and illness.

Inefficient Energy Use

Numerous exterior lighting characteristics contribute to inefficient use of energy. Certainly, any lighting that is not serving its intended purpose (effective illumination of the intended objects or surfaces) results in wasted energy. Following are several conditions indicative of inefficient energy use attributable to exterior lighting.

Inappropriate Lamp/Fixture Selection

In principal, lighting energy efficiency is most readily assessed by determining the lumens per watt emitted by the light source. Generally, the lower the lumen output per watt, the less energy efficient the light source is. Thus, selection of fixtures/luminaires having inferior efficiency characteristics compared to others available contributes to inefficient energy use. Additionally, inefficient lighting may result from ineffective installation/placement of fixtures/luminaires, regardless of the actual efficiency characteristics of the units themselves. Full-cutoff photometrics, insufficient pole height and other design criteria may result in the installation of more lighting units than is necessary to provide an acceptable level of lighting uniformity, thus consuming additional energy and increasing costs.

Outdated/Obsolete Existing Lighting

Lighting equipment, if properly maintained, can last indefinitely. As components such as lamps and ballasts fail, they are replaced in kind, thus providing years of service. While this practice may prove to be economical from a maintenance perspective, it does not provide for any efficiency improvements with advances in luminaire technology. The best example of this can be seen in the number of mercury vapor lamps still in use today. These lamps consume considerably more energy than HPS lamps to produce a given amount of light. Additionally, lamp efficiency degrades over time during its functional life, with an attendant decrease in lumens per watt output. Dirt and grime accumulations from atmospheric pollutants on lenses, reflecting and diffusing components may further diminish the realized efficiency of the fixtures/luminaires.

Glare

Though many factors contribute to glare, it often results when the source of light (the lamp or refracting/reflecting components of the fixture/luminaire) overwhelms the visual field. This has adverse effects on the eye's dark adaptation characteristics, often resulting in difficulties seeing intended objects or surfaces. Quality luminaries are available that control light to reduce or eliminate glare; their use should be encouraged.

Light Trespass

Light shining or reflecting onto property, which it is not intended nor desired, represents a poorly designed installation, since it both consumes energy and produces unwanted consequences.

Unnecessary Lighting

Exterior lighting operated when it is unneeded represents inefficient energy use. Exterior lighting that remains on during daylight hours results in wasted energy. Often this may be attributable to a control equipment malfunction or the need of adjustment and/or maintenance. Exterior lighting that remains on during daylight hours can also result from the inattention of a property owner to turn lighting off.

Excessive Lighting

Often efforts to enhance nighttime illumination are directed towards providing "more" lighting with insufficient focus on providing "better" lighting. Lighting levels that are higher than necessary contribute to inefficient energy use, often resulting in a "ratcheting up" of general lighting levels in the vicinity, particularly in commercial areas where lighting often is utilized as a means to attract business or present a proprietor's premises as more inviting to customers than a competitor's. The Illuminating Engineering Society of North America has established and published standards for exterior lighting prescribing recommended minimum values for adequate security and visibility needs.

Generation-Related Emissions

Consideration is given to the effect exterior lighting has on the environment aside from its visual impact on the night sky. Constellation Generation operates fossil fuel generating facilities in the region. The focus herein is directed towards emissions associated with the operation of fossil fuel facilities; hydroelectric and nuclear facilities are generally not considered to be major contributors of emitted pollutants.

The primary emissions associated with fossil fuel generating facilities are sulfur dioxide (SO_2) and nitrogen oxides (NOx). These emissions are measured in pounds per megawatt (lb/MW).

Brandon Shores is one of Constellation's primary fossil fuel facilities in the region. The SO_2 and NOx emissions rates of the Brandon Shores facility are considered representative of the industry. In recent years, the facility has been provided with enhanced emissions-reduction features. Brandon Shores[2] features two generating units. Capacity and emissions characteristics for those units are:

Unit 1	Capacity	635 megawatts	SO_2	11.8 lb/MW	NOx	4.5 lb/MW
Unit 2	Capacity	635 megawatts	SO_2	12.0 lb/MW	NOx	5.0 lb/MW

Example: Using the emissions rates for Brandon Shores, it is in theory possible to quantify emissions attributable to the use of exterior lighting. For the purpose of this example, exterior lighting at facilities operated by the Department of General Services (DGS) will be utilized. A survey of DGS facilities undertaken during September-October 2001 provided information on exterior lighting types, electrical consumption and other characteristics.

Considering an average operating time of 12 hours per night, 7 nights per week, calculations based on the survey data established the total annual electrical consumption for exterior lighting at all DGS facilities combined is approximately 1,293,401.96 kilowatt hours (1,293.4 megawatt hours)[3].

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[2] Brandon Shores emissions rates and supportive information provided by Charles Lacey Director of Outdoor Lighting, Baltimore Gas and Electric and Bonnie Johansen, Project Manager of Community Relations, Environmental Health and Safety Section Constellation Power Source.

[3] Department of General Services information provided by Robert Woodard, DGS Facilities Operations and Maintenance, Annapolis Complex.

Using the emissions rate figures for Brandon Shores Unit 2 (the unit having the higher emissions rate), the following calculations indicate approximate quantities of emitted SO2 and NOx:

SO_2:	12.0 lb/MW	X	1,293.4 MWHs	= 15,520.8 lbs per year
NOx:	5.0 lb/MW	X	1,293.4 MWHs	= 6,467.0 lbs. per year

It is evident that electricity used by exterior lighting at DGS facilities represents a substantial environmental impact. In any consideration of the emissions issue, it must be emphasized that reducing these emissions is not simply a matter of reducing the amount of electricity used by exterior lighting. Generating units operate at given capacities, producing the bulk of their emissions regardless of whether or not the total electrical capacity each unit provides is fully utilized. Large increases/decreases in electrical demand generally are facilitated by bringing additional units on line or shutting them down. Consequently, it would take very significant reductions in exterior lighting electrical use to have more than a marginal positive affect on emissions discharged. However, such conservation efforts, in conjunction with energy saving strategies applicable to other electrical usage, may indeed prove beneficial in reducing emissions by minimizing the amount of generating units the utilities must operate to meet the given demand.

Business Impact

Business entities utilize outdoor lighting for a number of reasons, including:

- To call attention to a place of business and attract customers;
- To showcase products and services; and
- To provide a safe environment for customers and employees.

Although tangible estimates are not available, some portion of the outdoor lighting used by businesses is inefficient in that it exceeds the amount needed to achieve the above objectives and/or is directed upward into the sky. Inefficient and excessive outdoor lighting used by businesses has a number of undesirable effects, including:

- Adding to the cost of consumer goods and services;
- Creating undesirable glare and light trespass;
- Contributing to air pollution as fossil fuels are consumed to produce the electricity used to power excessive lighting; and
- Contributing to undesirable sky glow

A representative of the Baltimore County Chamber of Commerce, Stuart Kaplow, came before the Task Force to share his organization's concerns that outdoor lighting regulations could impose additional costs on businesses in the state. He stated his organization's opposition to any statewide mandate requiring compliance with specific outdoor lighting standards. Mr. Kaplow urged that efforts to affect outdoor lighting practices by businesses be limited to educational programs.

A review of outdoor lighting policies in other states (see Appendix A) revealed that an unexpected cost of excessive outdoor lighting is the "ratcheting up" of lighting levels in an area where two or more businesses compete for the attention of customers. Competitive increases in outdoor lighting levels result in increased operating expenses to the businesses involved, and can be detrimental to the atmosphere of a "Main Street" or commercial area. This effect can be particularly troublesome where businesses are located near major roadways or residential areas.

Lighting Issues

Lighting Efficiencies

Numerous factors should be evaluated when determining the efficiency characteristics of a particular lighting installation. Purpose, installation costs, energy consumption costs, color rendition requirements and maintenance expenses must be considered. A particular lighting scheme may be economical to install initially, but prove costly to operate and maintain if it consumes excessive quantities of energy, must be serviced more frequently, or is more difficult to be serviced.

Below are general comments and efficiency characteristics of lamps commonly used in exterior lighting applications and some related data for typical highway luminaires.

Lamps

Lamps utilized in most outdoor lighting applications are known as High Intensity Discharge (HID) lamps. They are either High Pressure Sodium (HPS) or Metal Halide (MH).

Previously a third kind of lamp, the Mercury Vapor (MV) lamp was widely used. However, it is much less efficient than the other two sources and is not now used in new installations. There are several thousand MV lamps in service, which should be replaced.

HPS lamps are the most efficient light sources, providing the most lumens per watt, longest life, and the lowest Lamp Lumen Depreciation (LLD). However, they do not provide the best color rendition.

MH lamps are less efficient, have shorter life and higher LLD. However, they provide better color rendition.

Table 1, *Typical Lamp Efficiencies*, lists performance data for most of the HPS and MH lamps generally in use, with one listing of a MV lamp for comparison purposes.

The HPS lamp lumens are independent of lamp position. The MH lamp produces less lumens when mounted horizontally rather than vertically.

"Mean Lumens" is the average lumens over the rated life of the lamp incorporating the LLD factor and normally is used in a design. Several ballast designs can be used. The tabulation uses the "auto-reg" design, which is the most common design.

Luminaires:

There are many luminaire designs used in outdoor lighting. Table 2 lists the performance of some typical products. Three major factors influence the consideration of the design features in this study:

1. Luminaire Efficiency
2. Upward Light
3. Glare

The most efficient horizontal burning luminaire also has an upward component. The "post top" type of luminaire, with a vertical lamp, is the least efficient and, depending upon design, can produce a major upward component.

Designs with large high angle candle power (CP) produce the most glare. Codes, which control mounting height to low values, also result in systems with higher glare and closer pole spacings.

The Luminaire Cutoff Classifications described in Section 2.4.2 of the IESNA Roadway Lighting Standard, RP-8-00, are a function of the candlepower (CP) at the angles of 80 and 90 degrees nadir (0 degrees vertical). Luminaires classified as "Full Cutoff" generally are less efficient than those not so classified.

Most street lighting luminaires are designed to provide a major portion of the light on the Street Side (SS) of the luminaire. The downward SS and HS (house side) values help define the efficiency of the luminaire, but an overall proper system design is essential to produce an efficient system.

Table 1 *Typical Lamp Efficiencies*

Size (W)	Type	Initial Lumens	Mean Lumens	Life Hours	Ballast Input @	Lumens/ Watt	Relative Efficiency
70	HPS	6400	5450	24000+	87	63	65
100	HPS	9500	8550	24000+	127	67	69
175	MH-H	11700	7400	6000	206	36	37
175	MH-V	13600	8600	10000	206	42	43
150	HPS	16000	14400	6000	189	76	78
250	MH-H	19100	12400	6000	288	43	44
250	MH-V	20800	13500	10000	288	49	51
250	HPS	28000	27000	24000+	305	89	92
400	MH-H	33100	22100	15000	450	49	51
400	MH-V	36000	24000	20000	450	53	55
400	HPS	51000	45000	24000+	466	97	100
400	MV	22600	14400	24000+	454	32	33

Table 2 *Typical Roadway Lighting Luminaire Efficiencies*

(Comparisons based on high-pressure sodium (HPS) sources.)

Horizontal Burning "Ovaloid" with Refractor	CP per 1000 lumens 90 Deg	CP per 1000 lumens 80 Deg	Percent Light SS	Down-ward HS	Upward SS+HS
250 WATT SIZE – SEMI-CUTOFF	2.84	11.42	43.9	14.7	1.5
250 WATT SIZE – NON-CUTOFF	2.31	23.86	44.3	16.6	1.6
400 WATT SIZE – SEMI-CUTOFF	26.9	170.7	55.9	17.5	3.1
400 WATT SIZE – NON-CUTOFF	80.3	416.7	549	19	3.6

Horizontal Burning "Ovaloid" Full Cutoff	CP per 1000 lumens 90 Deg	CP per 1000 lumens 80 Deg	Percent Light SS	Down-ward HS	Upward SS+HS
250 WATT SIZE – FLAT GLASS	1.2	18.5	41.3	28.6	0
400 WATT SIZE – FLAT GLASS	0	10	45	31	0

Horizontal Burning "Rectangular" Full Cutoff	CP per 1000 lumens 90 Deg	CP per 1000 lumens 80 Deg	Percent Light SS	Down-ward HS	Upward SS+HS
400 WATT SIZE	0	43.6	43.7	33.9	0

Vertical Burning "Post Top"	CP per 1000 lumens 90 Deg	CP per 1000 lumens 80 Deg	Percent Light SS	Down-ward HS	Upward SS+HS
Contemporary with Refractor	114.2	206.6	24.4	15.3	8
400 Watt Size – Flat Glass	111.5	104.4	22.4	22.4	42

Lighting Technology

Evolution of Lamp Technology

Around the year 1821, streetlights were lit via natural gas. This mode of street lighting continued until 1879 when Thomas Edison experimented with and patented one of the first and most familiar types of light sources - the incandescent lamp. Although this invention was revolutionary at the time, certain factors, such as the inefficient production of light, led to researching other means of generating light.

In 1932, England's GEC (General Electric Corporation) introduced a commercially available arc lamp that used mercury vapor enclosed in a glass bulb. These lights quickly replaced many of the older tungsten-filament and carbon-arc lamps that were providing large-area lighting. Although popular, many found the blue-green color discharged by these lamps to be a bit garish. To this day, researchers have tried to overcome this drawback.

A short time later, Phillips, Osram and GEC introduced Low-Pressure Sodium (LPS) lamps in Europe. While these lights proved to be more efficient than their Mercury-vapor counterparts, their light output was less than desirable. LPS lamps produce a stark yellow light that makes everything appear yellow, black or some shade of gray. Dissatisfaction with the color of these lamps helped to drive further innovation in lamp technology. Throughout the 1950's, scientists experimented with various lamp coatings, ceramic materials and various pressures. This research resulted in the advancement of the High-Pressure Sodium (HPS) lamp.

In the mid-1960's, General Electric began research with dosing mercury-vapor lamps with halide compounds of various metals in an effort to improve color, save energy and preserve brightness. GE developed these lamps by adding iodine salts and other metals (indium, scandium, sodium and thallium). Iodine is one of the halogen elements, and thus a compound of a metal and iodine is called a "metal halide" salt. Metal Halide lamp technology continues to improve, and with the recent introduction of pulse start technology, may prove to be a viable cost effective alternative to HPS lamps.

In short, over the past 100 years, technological advances in lamps and lighting technology have enabled illumination so that most facilities can be used day and night. Millions of people can go shopping and travel the highways at night in comfort and safety. Light is one of the tools used to shape our built environment, visually and emotionally. Lighting design is a synthesis of light and shadow, color, form, space, rhythm, texture and proportion, achieved through an understanding of the technology necessary to produce these effects.

Reducing Light Pollution and Consumption

The most important determinants in the overall efficiency of a system are the luminaire, lamp and ballast. Technology in these areas is continually improving efficiency, not only to boost

existing equipment technologies, but also by developing new types of equipment altogether. Cutoff and semi-cutoff luminaires have been developed and refined over the years using combinations of reflectors and refractors in an effort to take more advantage of the upward flux of light output from a burning lamp. Early streetlights, and many currently available ornamental fixtures, were designed without such devices, and simply allowed the upward light flux to escape skyward. The reflectors and refractors used to distribute light from cutoff type luminaires are directing that light more efficiently than ever before, and taking full advantage of lamp output. This assures that if proper luminaires are chosen, that they are as efficient as possible at delivering light exactly where it is needed and not wasting it. This is evident in a comparison of a cutoff type luminaire, which directs light downward, with a non-cutoff type that may simply be a bare lamp behind a spherical glass globe. If each were used to illuminate a sidewalk, it would be evident that the cutoff type with a well-designed reflector is using the entire lamp output to light the sidewalk. On the other hand, the spherical luminaire is losing at least half of the total light output either to the sky, or to adjacent areas not intended to be lit. This not only increases the cost of the system, but also produces high levels of light pollution.

One drawback of the cutoff type luminaire is that it can require closer spacing of poles in order to achieve uniformity in the lighting design. This is because the majority of the light output is in a pool directly under the lamp. Recent developments in semi-cutoff optics are addressing this issue by allowing more light out of the fixture at closer angles to the horizontal. This has to be done carefully, however, so that glare is controlled. The goal is to allow enough light output from a luminaire to achieve vertical illumination and wider spacing of luminaires, without creating the glare associated with light output close to the horizontal plane.

In lamp selection, it seems intuitive that among the practical lamp choices, the lamp with the highest lumen output per input watt would be the obvious choice. This would be the high-pressure sodium lamp. But recent research seems to indicate that the yellowish color produced by the sodium lamp may not achieve the same level of visibility per lumen output as whiter light sources such as metal halide lamps that render colors more accurately and resemble daylight. Research also indicates that the whiter light source gives a higher comfort level to pedestrians because it is more natural and can aid in identifying other pedestrians and/or potential attackers more accurately. Lamp life also is a major factor in system efficiency because lamp changes can be expensive. Again, high-pressure sodium is the leader of the group in terms of lamp life among the most widely used types. There is a new lamp type emerging called the induction lamp, however, which combines the whiter light source of metal halide with lamp life reported to be as much as four times that of high pressure sodium. Ballasts are used to ignite the various gases used in these lamps; they, too, have associated efficiency ratings and should be selected appropriately.

There is no single, best answer to achieve efficient/cost effective lighting because there are an infinite combination of lighting applications and equipment technologies. The following are some general guidelines:

- Choose luminaires that distribute the light only where it is needed, minimizing light pollution.

- Choose appropriate lamp source color.
- Choose lamp types to maximize visibility per lumen output as well as maximizing lumen output per input watt of energy.

- Choose lamps with longer life ratings.

- Choose appropriate efficient ballasts.

- Design to appropriate lighting levels based on IESNA recommendations and do not over light.

- Layout lights to avoid spillover onto adjacent property, and choose appropriate pole heights.

Using these general guidelines will help design lighting systems that perform their intended function without wasting energy or causing light pollution and while minimizing installation, energy and maintenance costs.

Minimizing Inefficient Lighting [4]

There are numerous ways inefficient exterior lighting can be minimized, many of which are simply prudent, common sense approaches. The following practical efforts should be considered:

For Existing Exterior Lighting

Verify operating times and ensure lighting is turned off when not needed. Effective control of lighting may reduce wasted energy and produce costs savings as a result. The utilization of automatic controls should be considered where economical. For installations where dusk-to-dawn operation is necessary, photoelectric controls may be viable. Often, lighting for specific nighttime uses may be left on inadvertently after the need for it has ceased; programmable timers and related devices may be utilized to minimize these instances. Ensuring lighting is turned off when it is not needed is the most obvious, practical effort that can have an appreciable impact on lighting energy efficiency.

Maintain lighting equipment effectively. Control devices should be routinely inspected and/or adjusted where necessary to ensure they function accurately and dependably. Routine cleaning of light fixtures/luminaires can contribute to realizing maximum efficiency of the units. Keeping the units in good repair (replacing damaged lenses, reflectors, shields, etc.) can ensure maximum

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4 Minimizing Inefficient Lighting information provided by Robert Woodard, DGS Facilities Operations and Maintenance, Annapolis Complex, based on source materials published by Illuminating Engineering Society of North America and experience in government facilities operations exterior lighting applications and practices.

light is directed as designed and intended. Timely replacement of aging lamps that have depreciated in output can restore lighting to its maximum efficiency. Illuminated areas should be inspected periodically to ensure vegetation overgrowth has not developed, obscuring lighting or rendering it ineffective. Often a perceived need for additional lighting may be reduced or negated by effectively maintaining existing units already in place.

Retrofit existing fixtures with energy efficient lamps. There are numerous energy-efficient lamps and components available that can be utilized to enhance the energy efficiency of existing fixtures. This is particularly true with incandescent fixtures, of which a multitude of energy-efficient fluorescent and/or HID replacement lamps are available. Other fixture types may require replacement of the ballasts as well, but still be cost-effective verses replacement of entire fixtures. In particular, retrofitting of Mercury Vapor lamps/fixtures with more efficient HPS lamps and ballasts can yield substantial cost savings in both energy consumption and maintenance expenses. These may prove to be viable energy-efficiency enhancements for many exterior lighting applications.

Consider replacement of inefficient lighting components and systems**.** Though this may represent a substantial expense for large facilities, advances in illumination efficiency technologies have resulted in more efficient lighting equipment being available. In some instances, payback through realized energy savings may be an attractive incentive for facility operators to consider. Funding incentives may be available to entice owners of inefficient lighting systems to upgrade their outdated lighting.

For New Exterior Lighting Installations

Adequately assess the requirements for new lighting. Determine exactly what is to be illuminated (surfaces, objects, areas, etc.,) and the reasons for it (security, safety, aesthetics, etc.). Identify any special considerations (costs, color rendition needs, serviceability, etc.). Consider the lighting's impact on people and property (light trespass, glare, etc.).

Select energy efficient lighting components. Most lighting manufacturers today offer modern lighting equipment that has been engineered with energy efficient technology. Cutoff shielding, reflecting, diffusing and other design characteristics have been developed to reduce unwanted light trespass and glare while directing more of the lamplight towards an intended focus. Lamp technology has improved greatly in recent years, offering lamps with more efficient light output, better color rendition characteristics and longer, effective operating life. Fixtures/Luminaires should be thoroughly evaluated to determine their suitability for the application.

Efforts to identify the most energy-efficient lighting components and installation methods that will sufficiently meet given lighting requirements often may be best accomplished with the assistance of persons trained in modern lighting practices. Knowledge of IESNA and ANSI published practices and standards would be of significant value in achieving optimum results with minimum adverse impacts to the environment.

Available Standards and Practices

The following resources describing established standards and practices are available[5]:

IESNA Lighting Handbook, 9th Edition, Illuminating Engineering Society of North America (IESNA)

American National Standard Practice for Roadway Lighting, ANSI/IESNA RP-20-8-00, IESNA

Lighting for Parking Facilities, RP-20-98, IESNA

Lighting for Exterior Environments, RP-33-99, IESNA

Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) in Conjunction with Roadway Lighting, TM-10-00, IESNA

Light Trespass: Research, Results and Recommendations, TM-11-00, IESNA

Recommended for Walkways and Class 1 Bikeways, DG-5-94, IESNA

Recommended Practice for Sports and Recreational Area Lighting, RP-6-88, IESNA

Guidelines for Minimizing Sky Glow, CIE Report 126, 1997, Commission Internationale de Eclairage (CIE), Vienna, Austria

Guide to the Lighting of Urban Areas, CIE Report 92.1, CIE

Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, CIE Report TC-5. 12, CIE

Outdoor Lighting Code Handbook, Version 1.11, January 2001, International Dark Sky Association (IDA)

White Paper on Outdoor Lighting Code Issues, LSD 11 2000, National Electrical Manufacturers Association (NEMA)

Statement of Principals on Outdoor Lighting Codes, October 24, 2001, Luminaire Section of NEMA

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5 Information provided by Charles A. Oerkvitz, Illuminating Engineering Society of North America.

Addresses:

Illuminating Engineering Society of North America, 120 Wall Street, 17 th Floor, New York, NY 10005-4001

Commission Internationale de Eclairage, Publications may be ordered from: USNC/CIE, c/o TLA-Lighting Consultants, 7 Pond Street, Salem, MA 01970

International Dark Sky Association, 3225 N. First Ave., Tucson, AZ 85719

National Electrical Manufacturers Association, 1300 N. 17th St. Suite 1847, Rosslyn, VA 22209

Local Government Strategies

The State of Maryland is the largest single user of outdoor lighting in the state. Most of the state's outdoor lighting is installed and maintained by the Department of Transportation and the Department of General Services. Representatives of these agencies report that, at present, no formal guidelines or rules require compliance with existing outdoor lighting standards or guidelines. Increasing awareness of lighting efficiency and light pollution issues has contributed to improved outdoor lighting systems. However, the outdoor lighting practices of the State of Maryland remain uneven and inconsistent.

Currently, there are no state laws or regulations addressing outdoor lighting in Maryland. Any laws or regulations in effect would have been adopted and enforced at the local level. In fact, however, few local jurisdictions have adopted outdoor lighting regulations. The Task Force surveyed a number of local jurisdictions to determine the extent to which local government may be actively regulating outdoor lighting practices and to gauge the interest of local officials in the issue. A number of common themes surfaced from these interviews, including:

- With few exceptions, local jurisdictions have not adopted ordinances aimed at controlling outdoor lighting;
- Currently, there is no system of tracking the costs associated with inefficient or improperly installed outdoor lighting and most jurisdictions are unaware of the budgetary impact;
- Problems and complaints involving outdoor lighting, while not frequent, do surface occasionally;
- Most problems are resolved informally, while some problems are never resolved;
- Local officials would welcome and utilize information about outdoor lighting; and there is a particular interest in any standards or model regulations related to outdoor lighting.

Summaries of the interviews with county and municipal government officials can be found in Appendices D and E.