Technology Adoption Plan: Efficient Outdoor Area Lighting

I Introduction to Technology

Outdoor area lights are generally used in areas such as parking lots, commercial garages, walkways and courtyards. Types of area lighting fixtures include large area and structurally-mounted fixtures. Outdoor large area lighting represents one of the strongest growth opportunities in the area lighting segment. Large area lighting fixtures are used almost exclusively in nonresidential applications, making them very susceptible to swings in nonresidential construction activity. Shipments of these fixtures will also be supported by continued emphasis on providing safety and security in outdoor areas at hotels, industrial plants and other facilities. Accelerating construction expenditures in the nonresidential building segment makes outdoor area lighting fixtures one the fastest growing segment of the outdoor lighting market.

The type of fixture used for outdoor area lighting is greatly affected by the type of light source to be employed, which in turn depends on such factors as length of service, cost efficiency, light quality, brightness and ambient temperature. Outdoor area lighting fixture shipments are dominated by high-intensity discharge (HID) systems as the light intensity and long service life of these lamps outweigh their higher initial price. The predominant HID sources for most fixtures of this type are high pressure sodium (HPS) or metal halide (MH). Both HPS and MH lamps are gas-discharge lamps that operate under high pressure and temperature.

Other light sources that are used for some applications include incandescent and Light Emitting Diodes (LEDs). LEDs are semi-conductor devices that convert electrical energy directly into visible light. Most LED area lighting products and prototypes use high-power white LEDs.

Product developments in the outdoor area lighting fixture segment are focused on improving many of the performance characteristics, such as the efficiency and life span of the products. New outdoor efficient lighting technologies such as LEDs show promise in achieving such goals.

II Market Description and Barriers

The Climate Technology Initiative Team selected efficient outdoor area lighting based on established criteria such as commercial availability, demonstrated performance, potential cost effectiveness and diversity of players and technologies in the marketplace. These criteria are provided in Attachment A. This section provides more details on the outdoor area lighting market and presents the barriers that must be addressed for successful market penetration.

In the traditional outdoor area lighting market which has primarily used HID sources to provide illumination, there are many well-established large manufacturers of products that have been in the lighting industry for many years. Such leading US producers of these products include Acuity Lighting, Cooper Lighting, General Electric, Genlyte Thomas, and Hubbell Lighting. Within the newly emerging technology segments of the efficient outdoor area lighting market, smaller but well-established specialty lighting companies currently lead the industry. These smaller specialty manufacturers are able to adapt quickly to the new lighting technologies and more easily keep pace with its rapid advancement.

These manufacturers include the following:

USA outdoor area light fixture manufacturers:

- Acuity Lighting
- BetaLED
- Cooper Lighting
- General Electric
- Genlyte Thomas

- Hubbell Lighting
- IntenCity Lighting, Inc
- Lighting Sciences Group
- Lumec
- LuxBrite
- Relume
- Schreder Group GIE

International outdoor area light fixture manufacturers:

- Elettronica Gelbison
- Ledlight Group
- Stanley
- Leotech

Currently, HID fixtures dominate the area lighting market. The existing total U.S. market share of non-HID outdoor area lighting is 17%. See table below for the breakdown of number and type of parking lots lights in the United States in 2002.

Table 1: U.S. Outdoor Area Lighting Fixtures for Parking Lots, 2002

	Nationwide	Mercury Vapor	Metal Halide	High Pressure Sodium	Other (General Service Standard, Reflector Standard, Halogen Quartz, and Misc Fluorescent)
Parking Lot Lights	100%	20%	10%	53%	17%
	22,670,000	4,534,000	2,267,000	12,015,100	3,853,900

Source: Adapted from U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Program, U.S. Lighting Market Characterization, Volume 1: National Lighting Inventory and Energy Consumption Estimate, Final Report, September 2002.

Technical Performance

Outdoor area lighting accounts for 8% of the energy consumed for lighting use across the country.[1] The table below compares all of the technologies currently used in area lighting today.

Light Type	Data Sheet lm/W	Usable* lm/W	Lifetime (hrs)
Incandescent	17	10-17	3K
Halogen	20	12-20	10K
T12 fluorescent	60	45-50	20K
Metal halide	70	<40	5K-15K
T8 fluorescent	74	55-60	20K
Best-in-Class Power LED	87	65-75	> 50K
High-pressure sodium	91	<50	20K-24K
T5 fluorescent	107	96	20K
Low-pressure sodium	120	65-70	18K

[1] U.S. Dept of Energy, Energy Efficiency and Renewable Energy, http://www.eere.energy.gov/states/alternatives/lighting_daylighting.cfm

* Typical expected performance in real-life applications including typical fixture Coefficient of Utilization
(Adapted from Cree, Inc, LED Street Lighting PowerPoint Presentation, September 2007)

Potential Energy Savings and Environmental Impact

In a trial pilot program, the city of Ann Arbor, Michigan will become the first U.S. city to convert 100 percent of its downtown street light fixtures to an efficient outdoor lighting technology – LEDs – by installing more than 1,000 street light fixtures starting in November 2007, retrofitting all downtown lights over a period of two years. The city tested two new street lighting technologies —the test globe fixture, which use 50% less energy (48 to 56 watts compared to 100 watts of conventional fixtures), and the new cobra head fixture which uses up to 80% less energy (50 to 80 watts compared to 250 watts of conventional fixtures).[2]

For globe fixtures, the estimated annual energy savings is 228 kWh per fixture.[3] For cobra-head fixtures, the estimated annual energy savings is 877 kWh per fixture.[4] These fixtures are projected to last 10 years, replacing fixtures with bulbs that last only two years.[5]

Full implementation of the new efficient street lights is projected to cut Ann Arbor's greenhouse gas emissions by over 2,200 tones of CO_2. Annually, this translates to 203 kg of CO_2-equivalent emissions per globe and up to 781 kg of CO_2-equivalent emissions per cobra head.[6]

In addition to Ann Arbor, the City of Raleigh, North Carolina is currently undergoing a project to install over 500 high-efficient luminaires for a 365,000 square foot underground parking garage. A typical HID parking garage light fixture with 175-watt metal halide lamp consumes 210 total system watts each while the high-efficient alternative with five light bars consumes 118 total system watts each with equivalent light levels, providing a 44 percent energy savings.[7]

Other pilot projects include a street light installation in Racine, Wisconsin, a parking garage installation in Austin, Texas, and a parking ramp installation for the Mall of America in Bloomington, Minnesota.

Efficient outdoor area lighting products have also been installed in international locations including Toronto, Canada; Ede, Netherlands; University of Abertay in Dundee, Scotland; Tianjin Polytechnic University in Tianjin, China; Guangzhou, China; Split, Croatia; and Torraca, Italy.

Testing and Standards

In order to properly apply outdoor area lighting fixtures in an application, there are many recommended practices for application issues such as the placement of the fixtures, the level of light that should be on the ground surface, the uniformity of the light output, and limitations on uplight that can be emitted from the fixtures. Such recommended practices may also be required for certain applications due to the type of project (such as municipal or federal roadway illumination requirements), or due to certain ordinances that exist in the location (such as "dark sky" regulations that require all lights to produce minimal uplight). Most outdoor area lighting fixtures that are be used to illuminate commercial or roadway areas are photometrically tested so calculations can be made per application to verify the fixtures will meet the desired performance characteristics.

The illumination requirements for outdoor area applications current were all designed around HID technologies. As new technologies emerge, new testing protocols and recommended practices will need

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[2] C40 Cities, City of Ann Arbor profile: http://www.c40cities.org/bestpractices/lighting/annarbor_led.jsp
[3] Ibid.
[4] Ibid.
[5] LED streetlights to take over downtown Ann Arbor, LED Magazine, http://www.ledsmagazine.com/news/4/10/23
[6] C40 Cities, City of Ann Arbor profile: http://www.c40cities.org/bestpractices/lighting/annarbor_led.jsp
[7] LED City Initiative, http://www.ledcity.org

to be developed to address the different performance characteristics of emerging technology sources. For instance, LED fixtures produce more light directly on a ground surface due to their directional nature, but may not necessarily produce the prescribed numerical values that are required per the existing recommended practices. These fixtures can have an obviously improved perceived performance within the application, but the measured numbers may not reflect these perceptions. Thus, more research, evaluation, measurement techniques, and standard development may be required in order to accurately measure these new sources.

Existing recommendations and testing protocols for outdoor area lighting include

- Recommended Lighting for Parking Facilities (IESNA RP-20)
- Recommended Lighting for Roadway (IESNA RP-8)
- Technical Memoranda for addressing Obtrusive Light (TM-10)
- Technical Memoranda for addressing Light Trespass (TM-11)
- Technical Memoranda for addressing LED Sources and Systems (TM-16)
- Photometric Testing of Roadway Luminaires using Incandescent Filament and HID (LM-31)
- Photometric Testing of Roadway Lighting Installations (LM-50)
- Photometric of Parking Areas (LM-64)
- Interpretation of Roadway Luminaire Photometric Reports (LM-69)
- ASSIST Recommends, Visual Efficacy – Vol. &, Issue 1 (in press)

Cost Effectiveness
See table below for fixture price range by lamp type.[8]

Table 2: Costs of Outdoor Fixtures, 2007

Lamp Type	Price Range (Approximate)
150 Watt Metal Halide	$150 to $300
High Pressure Sodium	$150 to $200
LED	$700 to $1,500

In the case of the city of Ann Arbor efficient street light pilot initiative, each retrofit fixture costs approximately $460 with a pay back period of 4.7 years. The current maintenance costs for existing metal halide lights over a period of 10 years total $1,661 compared to $698 for efficient street lights in the same time period, resulting in a 42% more in cost savings for efficient outdoor area lighting technologies.

III Target Customers and Program Partners

The following U.S. area lighting fixture manufacturers are poised (i.e., commercially available product, current installations, demonstrated performance) to participate in the Climate Choice Program: Acuity Lighting, BetaLED, Cooper Lighting, General Electric, Genlyte Thomas, Hubbell Lighting, IntenCity Lighting, Inc, Lighting Sciences Group, Lumec, LuxBrite, Relume, and Schreder Group GIE.

In addition, the following stakeholders should be brought into early discussions for potential partnerships: C40 Cities, Climate Leadership Group, Lighting Research Center, The City of Ann Arbor, and Cree Inc.

[8] Lighting Research Center, N. Narendran, Jean Paul Freyssinier, Yimin Gu, *"Can the present white LEDs cater to the lighting needs?"* Presentation, June 2007

Applicability to EPA Skills
Under the Green Lights program and current ENERGY STAR Residential Lighting Fixtures program, EPA has worked closely with members of the lighting industry to help transform the market toward high efficiency technologies. EPA has existing knowledge of existing and emerging lighting technologies and has experience bringing together key stakeholders such as manufacturers, utilities, and retailers to develop a program that drives demand for increased efficiencies.

IV ENERGY STAR® Potential

The following is a list of ENERGY STAR Guiding Principles that EPA uses to determine whether or not a product category should be considered for ENERGY STAR specification development:

- Significant energy savings will be realized on a national basis.
- Product energy consumption and performance and can be measured and verified with testing.
- Product performance will be maintained or enhanced.
- Purchasers of the product will recover any cost difference within a reasonable time period.
- Specifications do not unjustly favor any one technology.
- Labeling will effectively differentiate products to purchasers.

The following milestones would need to be met for EPA to consider efficient outdoor area lighting under the ENERGY STAR Labeled Products program:

- Availability of a verified, industry accepted, and (laboratory) repeatable test procedure for measuring and comparing source life and lumen depreciation and photometric measurement.

Additionally, the following issues need to be examined prior to determination of the potential for ENERGY STAR labeling:

- ENERGY STAR lighting products have historically been residentially-focused only. Products in this segment are used in non-residential spaces.
- An established testing mechanism for evaluation of photopic versus scotopic lighting in public spaces

V Implementation Plan

EPA will spend the first phase of this project (i.e., March – September 2008) meeting with potential program partners; gathering, verifying, and analyzing existing data (e.g., pilot programs, performance testing); establishing proper performance standards; identifying existing relevant performance metrics; identifying opportunities to partner in a pilot program. Key elements of the implementation plan are provided below:

Finalize efficient outdoor area lighting performance specifications. A Draft specification plan will be shared with a small group of industry partners and discussed Jan. 2008 – April. 2008. The draft specification will include the necessary requirements for an efficient outdoor area lighting fixture to be included in the program. The specification will be refined and finalized by late April/early May based on feedback received from the industry group and will be ready to evaluate potential products and projects.

Recruit Program Partners. From April – May, meetings will be scheduled and conducted with outdoor area lighting manufacturers, industry associations, product users, and illumination source manufacturers. Potential pilot programs will be lined up in time for 2nd Qtr 2008.

Evaluate Pilot Programs. EPA will collect, analyze, and verify data throughout the first phase of this Plan. EPA will not conduct its own primary data collection but rather review data made available by manufacturers and other industry stakeholders. Also, EPA will review results from various pilot installations already conducted in the U.S. through other initiatives. Based on this evaluation, EPA will identify lessons learned, refine current approaches, and expand the pilot program to other projects and products in the U.S.

Attachment A: Assessment of EPA Selection Criteria

Key ● Favorable ◒ Satisfactory ○ Weak (Alternative: score, 0-10)	Commercially Available	Not widely adopted	Multiple Suppliers	Capable business partners	Demonstrated Performance	3rd Party Standards	Significant potential to reduce GHG	Potential to be cost competitive	Matched to EPA skills
Outdoor lighting	●	●	○	●	◒	○	●	●	●