The California Statewide Outdoor Lighting Baseline Assessment

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ABSTRACT

Outdoor - night lighting is a highly visible energy and environmental feature, yet little is known about the technologies, impacts and energy consumption of this practice. The California Energy Commission's Public Interest Energy Research (PIER) Outdoor Lighting Baseline Assessment is the first major study of nighttime lighting in California. The objective of the study is to provide a baseline of outdoor lighting energy usage and key environmental factors that can be used to measure the impact of any code revisions.

This paper describes the development of metrics for an exterior lighting assessment. What lessons were learned in performing the phone and field surveys? What field data was collected by what means and tools? What are the most relevant parameters to measure?

The analytical methodology for estimating the statewide impact of outdoor lighting will also be described. How are the field survey inputs for each site converted into an estimate of the associated energy use? How does the analysis model deal with the key environmental effects such as glare and light trespass? What statistical tools are used to extrapolate the findings to the state?

Although the energy impact analysis is still in process, the experience from the development of the field and analysis tools will be valuable information for other outdoor lighting studies and the potential to measure the impacts of future outdoor lighting regulations.

Introduction

This paper summarizes the methodology RLW Analytics, Inc. (RLW) used to conduct the California Statewide Outdoor Lighting Baseline Assessment on behalf of the California Energy Commission's Public Interest Energy Research (PIER) Program. The goal of this study is to provide a baseline of outdoor lighting energy use and key environmental factors that can be used to measure the impact of any future code revisions.

We performed 1000 telephone surveys with building owners and property managers throughout California to assess the current types of outdoor lighting applications and to develop a proxy for the amount of outdoor lighting at each site.

We then completed 300 onsite surveys throughout California, using the results from the 1000 telephone surveys to guide the site selection process. The onsite survey instrument was designed specifically for this study and gathers all the necessary data to measure the relevant parameters. The results from the 300 onsite surveys will be extrapolated to estimate the statewide impact of outdoor lighting.

The level of interest nationwide in this project has been substantial. The lighting, environmental, utility and code communities are closely following the progress of our analysis and outcome. Examples of current applications and opportunities based on our findings are discussed in this paper.

Target Population and Sample Selection

The first step in conducting the statewide outdoor lighting baseline assessment was to define the study target population and develop an appropriate sampling plan. The target population studied was the outdoor lighting associated with existing commercial, industrial and multi-tenant apartment buildings in California. To minimize the likely relative precision of statewide estimates of energy usage and other factors, we needed to devise a method that would allow us to sample locations with large amounts of outdoor lighting with higher inclusion probabilities than locations with small amounts of outdoor lighting and at the same time would allow us to keep travel distances between sites manageable. Specifically, we needed to define a proxy for the amount of outdoor lighting associated with existing construction in small geographic areas of California to devise a stratified sampling plan.

Using the idea that the amount of outdoor lighting associated with existing commercial and industrial buildings in a geographic area is likely to be directly related to the amount of commercial activity in a geographic area, we developed a stratified sampling plan of zip codes in California using measures of commercial activity by zip code.

Driven by the requirement to have a sample frame from which we could select a sample of buildings stratified by the amount of outdoor lighting at the building within each zip code sampling class, we completed approximately 1000 telephone surveys with building owners and property managers in order to develop a proxy for the amount of outdoor lighting at the site. The 1000 surveys also serve as the mechanism for extrapolating the findings from the onsite data collection back to the population of existing commercial/industrial buildings in California.

Telephone Survey Sample Design

We used the 1997 Zip Code Business Patterns CD-ROM from the U.S. Census Bureau[1] to determine the amount of business activity in each zip code in California. To create a measure of the amount of business activity in each zip code in California, two quantities — the total number of employees and the average number of employees per business[2] — were examined for each zip code. These measures of commercial activity were selected because we believed that the amount of outdoor lighting associated with commercial buildings in an area is highly correlated with the amount of employment in the area. Specifically, buildings with large numbers of employees tend have large parking lots. Additionally, safety concerns tend to lead towards increased outdoor lighting in locations of increased human activity.

First, the average number of employees per business in each zip code was classified into one of the following categories: extra low, low, medium, high or extra high. Next, the total number of employees in each zip code was classified into one of five categories: extra low, low, medium, high or extra high. These classifications were designed so that the amount of employment (i.e. total number of employees) in each cross-classification was roughly equal. In other words, the amount of employment for zip codes with an extra low average

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[1] The most recent version of the Zip Code Business Patterns CD-ROM available was the 1997 version.

[2] The average number of employees per business was calculated as the number of employees divided by the number of businesses.

number of employees and an extra low total number of employees is roughly the same as the amount of employment for zip codes with an extra high average number of employees per businesses and an extra high number of employees.

Table 1 shows the number of zip codes in each cross-classification. The table also shows the cut-points used to classify the zip codes by the average number of employees per business. The cut-points for classifying the zip codes by total employment are not shown because they depend on the "average number of employees" classification. The greatest number of zip codes belong to the extra low average/extra low total cross-classification, while the extra high average/extra high total cross-classification has the least number of zip codes. Though the numbers vary greatly between the two cross-classifications, the amount of employment is roughly equal in each.

A sample of two zip codes was randomly selected for each cell in the matrix shown in Table 1, yielding a total of 50 sampled zip codes. We planned on surveying 20 buildings in each sampled zip code, or 40 in each cross-classification.

Table 1: Number of Zip Codes by Employment Categories

Average # Employees per Business	Total Employment				
	Extra Low	Low	Medium	High	Extra High
Extra Low (0.330 – 11.299)	1234	119	71	47	31
Low (11.300 – 14.151)	183	49	35	26	18
Medium (14.152 – 17.890)	143	35	27	20	14
High (17.891 – 25.743)	160	27	18	13	8
Extra High (25.748 – 3750.0)	236	24	14	9	7

Once we selected a sample of approximately 50 zip codes, we used the Select Phone CD-ROM published by InfoUSA.com to identify and enumerate each business in the selected zip codes. The Select Phone CD allows the user to query the CD's database for all records meeting certain criteria. For example, the user can retrieve all businesses in a certain zip code or city. Finally, a sample of businesses was randomly selected from each zip code. The sample of businesses was aggregated to the street address level in order avoid sampling the same building twice.

Some zip codes, particularly those in more remote areas, contained less than 20 buildings, making it impossible to complete 20 surveys in the zip code. When this occurred, we supplemented the missing surveys with additional surveys from the other sampled zip code belonging to the same cross-classification. We selected an additional zip code from the same cross-classification when the two zip codes combined contained fewer than 40 buildings.

Ultimately, we telephone surveyed 1005 buildings in 52 zip codes. The completed 1005 surveys of buildings became the sample frame from which the 300 sites were selected for onsite data collection.

Onsite Survey Sample Design

The next step in conducting the statewide assessment was to devise a method of selecting a sample of 300 buildings for an onsite survey of the outdoor lighting at the building. The unit of data collection and analysis was the outdoor lighting associated with each self-standing building. Model Based Statistical Sampling (MBSS™) methods (Wright, 1999) were used to design the onsite sample. The 1005 telephone surveys conducted for the initial market characterization provided a proxy of the amount of outdoor lighting at each building to be used as a stratification variable in the sample design. Specifically, the completed 1005 building telephone surveys became the sample frame from which the 300 sites were selected for the statewide assessment.

MBSS methodology was used to develop efficient sample designs and to assess the likely statistical precision. The target variable of analysis, denoted y, is the outdoor lighting energy use of the project. The primary stratification variable, the proxy for the amount of outdoor lighting at the site, is denoted x. A ratio model was formulated to describe the relationship between y and x for all units in the population.

For each building for which we had a completed telephone survey, we examined several key questions and developed a point scheme to devise a proxy for the amount of outdoor lighting at the building. The point scheme was based on the following information: the number of parking spaces in illuminated outdoor parking lots, the functional types of outdoor lighting (i.e., landscape lighting, walkway lighting, area lighting, entrance lighting, building-mounted lighting and building-highlight lighting) reported to be present at the building, the use of outdoor lighting as an important part of the building's business, the use of outdoor lighting to attract customers or illuminate showrooms, the occurrence of serving the public or customers at night, the existence and quantity of illuminated signs. This proxy for the amount of outdoor lighting at the building allowed us minimize the relative precision of our estimates by sampling buildings with large amounts of outdoor lighting with higher inclusion probabilities than buildings with small amounts of outdoor lighting within each zip code sampling class.

To design the sample for the statewide assessment, we treated each zip code cross-classification as its own sampling class. Within each sampling class, we stratified the sampling frame by the number of points that was used a proxy for the amount of outdoor lighting present at the site. We used 3 strata for each class and selected a sample size of 12 from each class.

Onsite Data Collection

The unit of data collection and analysis was the outdoor lighting associated with each street address. If the building was in a multi-building complex, we sought to identify the outdoor parking and other space associated with the selected building. If the parking and other space were common to several buildings, we allocated a suitable proportion of the total space to the selected building.

The onsite survey collected data on the site geometry, operating characteristics of the lighting system, lighting controls, luminaire information, measured performance of the lighting system, and a subjective evaluation of the lighting. The survey consisted of both daytime and nighttime data collection.

The daytime visit began with an interview of the site contact. The interview facilitated the collection of data not easily (or always) observable by the site surveyor. Daytime data collection involved measurement of the site, identification of lighting controls and scheduling information, luminaire information, and layout of two illuminance grids (if possible) in sidewalk, security or parking areas. The performance of the lighting system was assessed at night through several measurements: illuminance grids for both parking lot and pedestrian areas, glare ratio[3] readings, light trespass[4] readings, and a subjective evaluation of the lighting system by the surveyor, and when possible other users of the surveyed space.

The nighttime assessment was important to help determine whether the lighting system as it performs is sufficient, over-designed, or under-designed. An over-designed lighting system is one which the amount of lighting produced exceeds the amount that is required to perform visual tasks at night or produces a lot of glare, which can impede nighttime vision. An under-designed lighting system is one that the lighting is not sufficient to perform visual tasks at night. Additionally, the subjective assessment helped evaluate the overall "quality" of the nighttime visual environment, to help researchers understand what factors are important to visual tasks at night.

Site Background Information

A series of data were collected at the building level. This information will be useful in providing a context for interpreting the remaining data gathered at the site. Background information on the building included the overall site area (in square feet), building footprint (in square feet), overall building floor area (in square feet), and the function of the building. Daytime and nighttime weather conditions, an assessment of the amount of ambient brightness in the surrounding neighborhood at night, a subjective assessment of the overall adequacy of the lighting at the site, and a subjective assessment of whether the lighting at the site creates glare were all also recorded by the surveyor.

Functional Use Areas

The initial component of the onsite data collection required the onsite surveyor to become familiar with site geometry, layout, and property lines. At smaller sites, this is relatively simple, but at larger sites, the site contact is often critical and can provide a site map, greatly reducing the amount of time required. Once the surveyor is familiar with the site, he or she must declare up to five functional use areas that adequately describe the majority of the functional uses of exterior lighting at the site from the following list: parking, pedestrian and walkway, landscape, outdoor retail sales (for example, car lot), internal roadway, storage, ATM, recreation, no use, façade and aesthetic, security, point of sale (for example, fast food), entry (if lit differently from walkways), and gas station canopy.

It is most important that the functional use areas at the site adequately describe the majority of uses of the exterior lighting at the site. Area of the site that was unlit was not included in any functional use areas, therefore the resulting measurements produced square footages associated with up to five FUAs, total property square footage, and unlit square footage. The following components of data collection were all completed at the functional use area level.

[3] The glare ratio is defined to ratio of the number of foot candles resulting from the light source to the number of foot candles provided by the ambient light.
[4] Light trespass is defined to be light falling where it is not wanted or needed, or obtrusive light.

Operating Characteristics of Lighting Controls

The operating characteristics of the lighting controls are essential to estimating the statewide energy consumption attributable to outdoor lighting. These data provide the hours of use of the exterior lighting at each site at the functional use area level. The site contact provided this information during a short interview as a part of the daytime data collection.

For each functional use area (for example, parking, walkway, ATM, etc.) of the site, we collected the control mechanism for the exterior lights. If the exterior lighting was controlled manually or by a time clock, the operating schedules were also recorded. Separate schedules were collected for summers, winters, weekdays and weekends. Some buildings used a photocell to turn on the exterior lights and a time clock to turn them off. In these cases, we recorded the use of both operating controls and the time the lights turned off.

Luminaire Information

All information specific to the luminaire equipment was recorded by functional use area for each site in the sample. These data will be valuable for both estimating the statewide energy consumption and assessing the lighting system design. In addition to the specific technical information on the luminaire, we provided a data field for a subjective condition evaluation of the equipment. This is intended to help explain why one installation does not appear to perform as well as a similar installation at another site.

For each functional use area at the site, the following luminaire information was recorded: luminaire type designation, general location on the site (for example, parking lot, building soffit, etc.), quantity of equipment on site, lamp technology type (for example, metal halide, high pressure sodium, etc.), ballast type (if applicable), lamp wattage, luminaire mounting height, and condition of luminaire (good/fair/poor).

The luminaire type designation comes from a luminaire type catalogue created specifically for this study and is intended to be universal for the entire study. This will ensure that a type “A” luminaire in every site will be from the same family of luminaires throughout the onsite data collection. The luminaire catalogue contained separate designations for the lamps and the fixture types, allowing the surveyor to select any number of luminaire combinations.

Illuminance Readings

We recorded illuminance readings of the parking lot, sidewalk or security lighting at each site in the sample, if feasible. A reasonable assessment of the parking lot lighting can be made with readings taken at nine points in a typical parking lot, and six points on a typical lighted sidewalk. The security lighting requires six points if the lighting is similar to a sidewalk, or nine points if there is a more extensive security lighting system. The location of the grid was established based on the layout of the luminaires or luminiare poles.

These six or nine points make up a “grid” of three-by-three for the parking lot, and two-by-three for the sidewalk lighting. There are five illuminance readings taken at each point in the grid: a horizontal reading at grade, and four vertical readings, one at each compass quadrant.

The surveyor also sketched any geometry that will affect the light level readings, including buildings, walls and trees, and also provided information on burnouts and other conditions that affect the system performance.

In addition to the five illuminance readings taken at each of the grid points (one horizontal and four vertical readings), the surveyor also recorded the locations of the lighting equipment affecting the readings relative the locations of the readings, and the locations of any geometry and physical characteristics that affect the readings.

These readings will allow researchers to assess uniformity in parking lot and sidewalk lighting design and to examine average, minimum, and maximum illuminance levels.

Glare and Light Trespass

Glare and light trespass measurements were only taken if there was at least one fixture on the site that appeared to be creating glare or light trespass. Separate attachments to the light meter were used for the glare and light trespass readings.

To measure the glare ratio at the location, two illuminance readings of the glaring fixture and the location of the readings relative the remainder of the site were recorded. Using a special snoot type attachment, a reading directly below the fixture with the snoot pointing up to measure the foot candles resulting from the light source, and a reading with the snoot pointing down to measure the foot candles of the ambient light were each documented. Up to three sets of glare readings at each site were collected.

A measurement of the light trespass of the offending fixture was taken. The location of the offending fixture relative to the remainder of the site was also recorded. A special attachment to the light meter is required; one similar to the glare snoot was used for this purpose. This attachment is pointed directly at the offending fixture from the property line, using line of site as the measurement angle. The highest reading was recorded.

Subjective Evaluation of Lighting

This portion of the onsite survey instrument asks a series of questions to help determine whether the lighting on the site is adequate, and whether the quality of the visual environment is sufficient for the safe use of the space at night, as well as the perception of safety within the space. The study borrowed the subjective outdoor lighting survey from the Rensselaer Lighting Research Center.

Analytical Methodology

Onsite survey data regarding the operating characteristics of the lighting controls and the technical luminaire information will be compiled and analyzed to estimate the annual energy consumption of outdoor lighting in California. Case weights and site level estimates of energy usage will be combined to extrapolate the sample findings to the target population. Lighting power densities (LPD) by functional use areas and building type as well as the prevalence of luminaire types and lamp types will also be examined.

The illuminance readings in the parking lot and sidewalk grids as well as the glare and light trespass readings will be used to assess lighting system design. These data will be used to assess uniformity in lighting system design, minimum, maximum, and average illuminance levels, and the relationship between glare and uniformity in lighting design. Additionally, the measured illuminance levels and glare readings will be compared to the subjective assessments of the site lighting to determine what (if any) relationship exists between lighting levels and perceptions about the adequacy of the lighting.

Site Level Annual Energy Usage

To estimate the statewide annual energy consumption of outdoor lighting, the field data collected for each site must be converted into an estimate of the annual energy use. The operating control data and the lighting schedules determine the annual operating hours of fixture i. The lamp type, number of lamps, lamp wattage and ballast type (if applicable) approximate the wattage of luminaire i. For each site, the annual operating hours of each fixture and the fixture wattage is combined to estimate the annual energy consumption attributable to outdoor lighting. The following equation illustrates the calculation:

Equation 1. Site Level Annual Energy Usage Calculation

$$Annual\ kWh = \sum_{All\ luminaires} h_i * \frac{W_i}{1000}$$

Where h_i = Annual operating hours of luminaire i

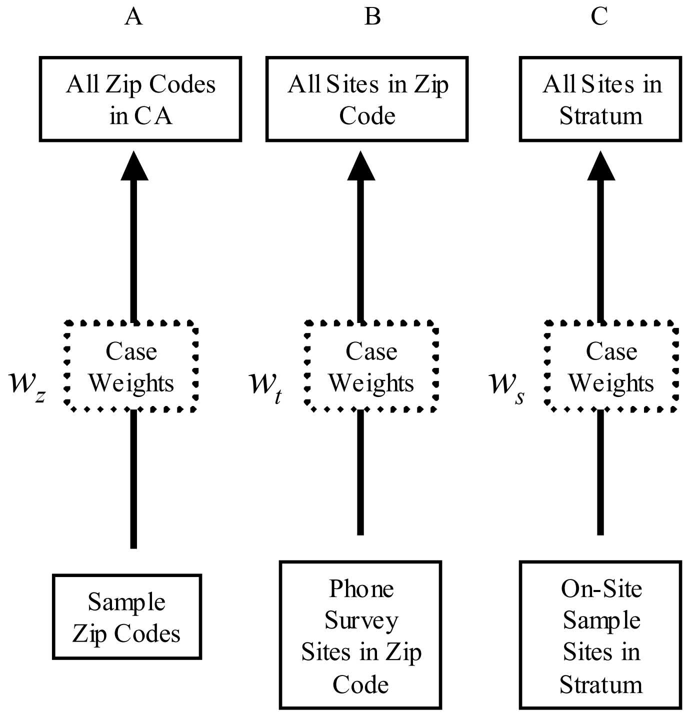
And W_i = Wattage of luminaire i

Case Weights

In analyzing sample data, case weights are generally used to extrapolate the sample sites to the target population. The case weight w_k is the key to unbiased extrapolation from the sample sites to the target population.

Each site in the onsite survey sample has a corresponding case weight that will be used to extrapolate the findings to the state of California. The following figure illustrates the methodology that will be used to calculate the case weight of a site k belonging to a certain sampling class j:

Figure 1. Calculating the Case Weights



$$w_k = \text{Case Weight of Site k}$$

$$= w_z \ast w_t \ast w_s$$

where

$$w_z = \frac{\text{\# Zip Codes in CA in Class j}}{\text{\# Zip Codes Sampled from Class j}}$$

$$w_t = \frac{\text{\# Business Listings in Class j}}{\text{\# Business Listings for Building Address}}$$

$$w_s = \frac{\text{\# Sites in Stratum i of Class j}}{\text{\# On-Sites in Stratum i of Class j}}$$

As Figure 1 shows, the first step in calculating the case weight of site k belonging to stratum i of sampling class j was to calculate the weight that will be used to extrapolate the on-site survey data to the sampling frame used to select the on-site survey sample, w_s. In this study, the sampling frame used to guide the on-site survey selection was the telephone survey sample. Consequently, w_s is equal to the number of sites in the telephone survey sample belonging to stratum i of sampling class j divided by the number of on-site surveys in that stratum. In essence, w_s is used to extrapolate the on-site survey data to the telephone survey data.

Next, the weight that extrapolates the telephone survey data to the zip code sampling class j, w_t was calculated. As seen in the figure, w_t is equal to the total number of business listings in sampling class j divided by number of business listings associated with the street address of the building, since the unit of data collection and analysis was the outdoor lighting associated with each street address.

The third step in calculating the case weights was to calculate the weight that extrapolates the sampled zip codes to all zip codes in California, w_z. The weight associated with each zip code is equal to the number of zip codes in California in sampling class j divided by the number of zip codes sampled from sampling class j. The zip code sampling classes are those previously described in the telephone survey sample design section. Lastly, the case weight of site k belonging to stratum i of sampling class j, w_k, is equal to the product of w_s, w_t, and w_z.

Extrapolation of Results

The case weights will be used to extrapolate the sample findings to the state of California. Two types of estimates must be extrapolated the population: estimates of population totals (e.g. annual kWh energy consumption due to outdoor lighting in California) and ratio estimates (e.g. average LPD in parking lots).

Population Totals

The mean per unit estimate of population totals will be calculated as a weighted sum of the sample observations. For example, the statewide annual energy consumption of outdoor lighting will be estimated using the following calculation:

$$\hat{Y} = \sum_{k=1}^{n} w_k y_k ,$$

Where y_k = the annual energy consumption of exterior lighting at site k

And $\hat{Y}$ = the statewide annual energy consumption of exterior lighting.

Ratio Estimates

For each site *k*, the characteristic of interest is often a ratio $R_k = y_k / x_k$, e.g., kWh per square foot. In general MBSS terminology, y_k is called the dependent variable and x_k is the explanatory variable.

Then the population characteristic of interest is the ratio $R = \frac{\sum_{k \in P} y_k}{\sum_{k \in P} x_k}$. The preceding equation can also be written as $R = \frac{\sum_{k \in P} x_k R_k}{\sum_{k \in P} x_k}$. In this form it is evident that *R* is a weighted average of the values of R_k for all sites in the target population.

Generally we do not the values of both y_k and x_k for all sites in the population. But for each site in the sample, we do have a weight w_k that can be used to extrapolate the sample to the population. In this case we calculate an estimate of *R* that is denoted $\hat{R}$ and calculated using the equation: $\hat{R} = \frac{\sum_{k \in s} w_k y_k}{\sum_{k \in s} w_k x_k}$. The preceding equation can also be written as

$$\hat{R} = \frac{\sum_{k \in s} w_k x_k R_k}{\sum_{k \in s} w_k x_k}.$$

Illuminance and Glare Measurements

An analysis of glare will be performed. The up reading for glare divided by the down reading for glare provides the glare ratio for the location at the site. The relationship between horizontal uniformity (defined as the ratio of the maximum horizontal illuminance reading in the grid to the minimum horizontal illuminance reading) and the glare ratio will be examined. We will also look at the relationship between the minimum, maximum and average horizontal illuminance readings and the observed glare ratio. The results, in conjunction with the subjective survey evaluations of the quality of the nighttime lighting, could provide valuable insight into the creation of appropriate exterior lighting design requirements that will yield exterior lighting systems that provide adequate lighting levels while consuming less energy.

Lessons Learned

Several lessons were learned throughout the course of conducting the phone and onsite surveys. The key points are listed below.

- The onsite survey instrument and database that houses the onsite survey data must be designed to be flexible enough to capture a myriad of outdoor lighting applications. Even though pilot tests of 50 buildings were used to design the survey instrument, we still encountered unanticipated outdoor lighting applications that necessitated either revisions to the instrument or special handling in the database.
- The illuminance measurement grids should be defined at night right before the readings are taken. During the pilot test of the onsite survey instrument, we were defining the placement of the illuminance measurement grids as a part of the daytime component of the onsite survey. When we returned at night to take the measurements, we often found cars or other objects obstructing the grids defined during the day, requiring the grids to be redefined.
- Horizontal and vertical illuminances directly beneath or between equipment, as well as line of sight toward equipment when off the property, are thought to be the most relevant parameters to be measured in assessing lighting system design. These parameters can be measured cost effectively by surveying typical areas. The best ways to calibrate the measurements are to use similar illuminance meters that have been recently calibrated and to establish a measurement technique so surveyors do not shadow the readings.

Uses of the Findings

The results from this survey will provide a basis for ongoing discussions of program and code options for addressing outdoor lighting energy use. The baseline findings, survey methodology, energy metrics and the environmental assessment are already influencing nationwide discussions of exterior lighting. Some examples follow.

California Senate bill SB5X was signed into law in 2001. It provided that the California Energy Commission (CEC) could develop standards for and regulate outdoor lighting. Previously, the CEC was restricted to regulating lighting only for conditioned space.

Work is currently underway to develop an outdoor lighting standard based in part on this work. If successful, this initiative would become effective in 2005.

In Washington, both Seattle and the State have had exterior lighting requirements since 1980. Both codes prohibit trading between interior and exterior lighting and categorize exterior lighting into two broad groups: facade lighting and all else. The wattage allowances are applied to the square foot of illuminated area (Hogan 2002). A representative from the City of Seattle is an advisor to this PIER research and is providing valuable feedback on the application of their code approach. This project's findings, in turn, will provide expanded category definitions and characteristics beyond the current "all else" grouping in Washington, including such areas of high interest as gas station and parking lot lighting.

A consortium of lighting experts and entities, lead by the International Dark-Sky (IDA) is developing a Model Lighting Ordinance (MLO). The MLO Task Force was formed in early December 2001. As the CEC develops a scientific basis for outdoor lighting regulation, based in part on this survey, the MLO Task Force will incorporate results as appropriate to the outdoor lighting section of their national model ordinance.

The intent of the MLO for outdoor lighting will be to restrict unnecessary and improper uses of outdoor lighting by a combination of cutoff requirements, height limitations, power density limits, and other factors that still permit the interpretation and application of Illuminating Engineers Society of North America (IESNA) recommendations by individual lighting designers, engineers and others. The work will be based on IESNA, CIE (International Commission on Illumination) and other applicable standards to the maximum extent possible (Benya 2001).

Results may also feed into key lighting design guides such as the IESNA handbooks and recommended practice guidelines, the ASHRAE/IESNA 90.1 lighting standards, and the Advanced Lighting Guidelines. In addition, several utilities and state energy offices intend to replicate the survey methodology in order to create a baseline analysis in their territory.

The assessment methodology described in this paper is highly valuable as a repeatable protocol for the establishment of outdoor lighting baselines. Combined with the interest and activity of transferring this research into programs, policies and practices this survey method will play a key role in reducing outdoor lighting energy use.

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