Development of Interior Lighting Hours of Use and Coincidence Factor Values for Evaluation of the EmPOWER Maryland Commercial Lighting Programs

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ABSTRACT

The issue of whether and how estimates of lighting Hours of Use (HOU) and Coincidence Factors (CF) for different building types can be transferred or extrapolated between states is very important for states looking to avoid having to devote significant amounts of resources for on-site measurement studies. This study reviewed estimates from five states, and developed a method to extrapolate lighting values from a California study with large sample sizes to Maryland commercial lighting programs.

Itron leveraged the time-of-use (TOU) lighting logger data from a recent evaluation of California's 2006-2008 nonresidential lighting programs to develop HOU and CF values for compact and linear fluorescent lamps for 13 building types. The California Lighting Study was used because:

1) It is the largest study of its kind. Nearly 7,000 lighting loggers were installed in over 1,200 commercial buildings throughout California.
2) The original study was conducted by Itron, so the underlying data were readily available.
3) It provided high precision/confidence estimates for almost all of the building types.
4) The granularity of the data is sufficient to allow generation of both HOU and CF values for Maryland from the same 8760 hour dataset.

This paper compares and contrasts values used in various TRMs and commercial lighting studies throughout the United States, summarizes the results of the analysis (including confidence ranges), and fully describes the methods used including technical issues that must be addressed when applying evaluation results to other states or service territories. This paper will be relevant for anyone seeking to transfer evaluation study results from one service territory or state to another.

Overview

The EmPOWER Maryland Act requires utilities to reduce per capita energy consumption and demand by 15% by 2015.[1] Energy savings from commercial lighting programs could represent as much as a quarter of total EmPOWER Maryland energy savings for some utilities.[2] Given the need for commercial lighting programs to achieve a significant portion of the total portfolio savings, the analysis used to develop assumptions related to Annual Hours of Lighting Use (HOU) and Coincidence Factors

[1] *EmPOWER Maryland Energy Efficiency Act of 2008*, House Bill 374.
[2] Estimates based on reported kWh savings from the utilities' Third Quarter 2010 EmPOWER Maryland reports.

(CF) for commercial lighting systems will have a significant impact on both the reported savings for the program and the likelihood that the overall portfolio will meet the EmPOWER Maryland savings goals.[3]

As the independent statewide evaluator for the EmPOWER Maryland programs, Itron is responsible for reviewing existing commercial HOU and CF values available in Maryland, as well as recommending a set of consistent assumptions for use in evaluating the 2011 EmPOWER Maryland commercial lighting programs and developing ex ante estimates of savings from these programs in the 2012-2014 program portfolios. Itron's objective is to provide recommendations that are well documented in terms of data sources and methods, based on data or studies that are less than five years old, and applicable to the technologies promoted in the EmPOWER Maryland programs.

Itron developed HOU and CF values to be used as ex ante assumptions in the Maryland EmPOWER utilities' program tracking systems for 2011, program planning filings for 2012-2014, and the 2011 EmPOWER Maryland statewide evaluation. These values can and should be supplemented by lighting load data obtained from Maryland on-site data collection where available.

The values recommended in this paper are based on an Itron-led impact evaluation study of the 2006-2008 commercial lighting programs in California, referred to herein as the "California Lighting Study" (Itron 2009), supplemented by the California Database for Energy Efficiency Resources, or DEER (CPUC 2008). While the recommended values in this paper were developed specifically for the Maryland EmPOWER commercial lighting programs (Itron 2010), they may also be useful or applicable to other utility service territories or states in the Mid-Atlantic region. These estimates are being incorporated into the Mid-Atlantic Technical Reference Manual (TRM) developed by Vermont Energy Investment Corporation (VEIC) for the Northeast Energy Efficiency Program EM&V Forum.

This paper describes the methods used to develop building-specific values along with the statistical validity of the estimates, summarizes the results of the analysis, compares and contrasts the recommended HOU values to HOU values from other sources, and suggests possible explanations for differences in HOU and CF values from various sources.

Development of HOU and CF Values

In its role as independent evaluator for Maryland's EmPOWER programs, Itron compiled and compared HOU and CF recommendations from more than a half dozen sources (described in a subsequent section of this paper). All of these sources were in some way deficient. Some were insufficiently documented in terms of data sources and methods. Some were based on old data or studies that were not available for review (e.g., a study from 1993). Some did not provide HOU values for important building types or for areas within those building types where more resolution was needed (e.g., hotel common areas and guest rooms). One source provided CF values but without corresponding HOU values. Most sources were not based on actual lighting logger data, but instead used some form of self-report combined with building simulation models to estimate equivalent full load lighting HOU.

In an attempt to fill this gap and improve on these estimates, Itron leveraged data from the California Lighting Study to develop HOU and CF values for Maryland. Unlike the other studies examined, the California Lighting Study was based exclusively on primary lighting logger data. In sum, and as discussed in more detail below, Itron mapped the California Lighting Study building types to the Maryland building types derived from the Mid-Atlantic TRM (VEIC 2010 MidA TRM), applied the California Lighting Study HOUs to the Maryland building types, and developed CFs based on two different peak period definitions. For building types for which the California Lighting Study sample was too small to provide statistically reliable results, Itron supplemented with data developed for the 2006-2008 DEER update. The DEER values are derived from building simulation models based on the

[3] Coincidence Factor is defined as the fraction of load reductions that occur during a specified peak period window.

results of previous California lighting logger evaluations. While the DEER values are not based on lighting logger data per se, the DEER data were the next most reliable and comprehensive source of HOU and CFs available.

The California Lighting Study

The California Lighting Study evaluated multiple utility programs that rebated three nonresidential lighting "measure groups," namely linear fluorescents, high bay lighting, and screw-based compact fluorescent lamps (CFLs). The study examined both downstream lighting measures and upstream screw-based CFLs.[4] Three lighting technology categories were used because the commercial applications for each are quite different, and each of them alone represented a significant portion of the CA energy efficiency portfolio. In fact, upstream CFLs alone were responsible for the largest portion of savings for the CA 06-08 energy efficiency programs, and as such, the CFLs were split by delivery method (upstream and downstream) to examine any differences in the location and operation of CFLs for each category.

On-site surveys were conducted and lighting loggers were installed at sites across California covering the service areas of the State's four major investor-owned utilities. The study results were intended to be used for a variety of applications, including the development of HOU and CF values by building type and space usage type, whenever possible. Key aspects of the study that are relevant to this current analysis are as follows.

- **Lighting Groups.** Four lighting groups were used for this study—downstream CFLs, upstream CFLs, linear fluorescent, and high bay lighting.
- **Program Delivery Type.** Lighting measures delivered by upstream, prescriptive rebate, and direct install program types were evaluated.

Extensive and detailed analysis results are presented in the report for every utility by lighting group, program delivery type, and building and space usage type (e.g., office, hallway, bathroom).

For the Maryland analysis, lighting groups and program delivery types were condensed and aggregated to make the results more robust and more consistent with the existing Mid-Atlantic TRM format. For some building categories, the California Lighting Study data were not statistically valid, in which case values from DEER were used.

The California Lighting Study was used as the basis for HOU and CF estimates for the following reasons:

- With a sample size of 6,774 loggers installed in over 1,202 sites for two to three months each, it is the largest and most comprehensive study of lighting use ever conducted;
- The original study was conducted by Itron, so the underlying data were readily available and their limitations were understood;
- It provides HOU estimates for almost all of the 12 building types with high precision/confidence; and
- Both HOU and CF values can be generated from the same lighting logger dataset by reprocessing the original CA data using the definitions of peak periods used in Maryland.

[4] Downstream measures are those distributed either by direct installation (via an implementer/contractor) or that received a rebate, while upstream measures are utility subsidized measures (mostly CFLs) sold at retail stores.

In sum, the Itron team believes the California Lighting Study is the best available source of data on nonresidential lighting HOU and CFs for a large population of customers.

Mapping California Lighting Study Building Types to Maryland Building Types

Building types and activity areas used for the California Lighting Study were mapped to a modified version of the Mid-Atlantic TRM building types, as shown in Table 1. There were two modifications to this basic set of building types used for the final Maryland analysis. First, the single "Hotel/Motel" building type was split into two sub-types: Guest Rooms and Common Areas. This split was needed because the HOU and CF values for these two distinct activity areas are markedly different, as shown in the California Lighting Study as well as others. Intuitively, common area lighting systems are much more likely to be on for significantly more hours per day and year than interior lights in guest rooms that are most often empty.

Second, HOU data from building types with low sample sizes in the California Lighting Study were combined and moved into the "Other/Misc." building type, as also shown in Table 1.

Table 1: Building Type Mapping Table

Lighting Group (CFL, Linear Fluorescent, or Both)	California Lighting Study Building Type	Activity Area	Modified Mid-Atlantic TRM Building Type
Both	Agriculture	All	Other/Misc.
Both	All Commercial[5]	All	Other/Misc.
Both	Assembly	All	Other/Misc.
Both	Education – Community College	All	Other/Misc.
Both	Education – Primary School	All	Elemen./Second School
Both	Education – Secondary School	All	Elemen./Second School
Both	Education – University	All	Other/Misc.
Both	Government	All	Office
CFL	Grocery	All	Other/Misc.
Linear Fluorescent	Grocery	All	Grocery/Supermarket
Both	Health/Medical – Clinic	All	Health
Both	Health/Medical – Hospital	All	Other/Misc.
CFL	Lodging	All Except Guest Rooms	Hotel/Motel – Common Areas
CFL	Lodging	Guest Rooms	Hotel/Motel – Guest Rooms
Linear Fluorescent	Lodging	All	Other/Misc.
Both	Office – Large	All	Office
Both	Office – Small	All	Office
Both	Other Industrial	All	Manufacturing
Both	Restaurant – Fast Food	All	Restaurant
Both	Restaurant – Sit Down	All	Restaurant
Both	Retail – Large	All	Retail
Both	Retail – Small	All	Retail
Both	Utilities	All	Other/Misc.
Both	Warehouse	All	Warehouse

5 "All Commercial" is the "Other" category for the California Lighting Study.

Consolidation of Lighting Groups

The California Lighting Study collected data from four types of lighting technologies promoted in different types of programs: Upstream CFL, Downstream CFL, Linear Fluorescent, and High Bay Lighting (linear fluorescent lamps installed in fixtures over 15 feet above floor level). For simplicity of application in Maryland, these four lighting groups were consolidated into two lighting groups (CFL and Linear Fluorescent), as shown in Table 2.

Table 2: Lighting Group Mapping Table

California Lighting Study Lighting Groups	MD Analysis Lighting Groups
Downstream CFL	CFL
Upstream CFL	CFL
Linear Fluorescent	Linear Fluorescent
High Bay Lighting	Linear Fluorescent

Annual Hours of Use

The HOU is the total annual hours of use for rebated lighting system in each given building type based on the data collected by the lighting loggers. This value was obtained by calculating the total annual HOU for each activity area at each site, and then aggregating these values to the modified Mid-Atlantic TRM building types by applying the same weights that were used for the California Lighting Study.

Coincidence Factors

The peak demand definitions used for the CF development are described in the Mid-Atlantic TRM. Excerpts are provided below.

- **PJM Peak Period:** "…For measures that are not weather-sensitive, peak savings are estimated whenever possible as the *average of savings between 2 P.M. and 6 P.M. across all summer weekdays* (i.e. PJM's EE Performance Hours for its Reliability Pricing Model)…"
- **EmPOWER Maryland Peak:** "*…peak savings during the most typical peak hour (assumed here to be 5 P.M.) on days during which system peak demand typically occurs (i.e., the hottest summer weekdays)*."

For this analysis, the methods used to develop the CFs corresponding to these two peak demand periods are as follows.

- **CFpjm:** This is the CF for the PJM peak period, developed from hourly lighting usage data from 2 P.M. through 6 P.M. during the summer (June 1 – August 31) non-holiday weekdays. This value was obtained by calculating the average hourly percent usage for each activity area at each site, and then, similar to the HOU calculation, aggregated to the modified Mid-Atlantic TRM building types, applying the same weights that were used for the California Lighting Study.

- **CFemp:** This is the CF consistent with the EmPOWER Maryland peak definition. This value was developed similar to the previous approach (i.e., summer, non-holiday, weekdays), but only the data for 4 P.M. to 5 P.M. were used to compute the CF.[6]

Statistical Confidence of California Lighting Study Estimates

The confidence and precision of the California Lighting Study estimates are generally high for both HOU and CFs. Table 3 provides sample size, standard errors, precision levels, and lower and upper bounds for estimates of linear lighting HOU. At the 90% confidence level, the precision levels (more accurately, levels of imprecision) do not exceed 15% for any building types included in Itron's recommendations.

Table 3: Statistical Confidence for Linear Lighting Hours of Use

Building Type	Number of Sites in Sample	Standard Error	Mean	Precision at 90% Confidence	90% Confidence Lower Bound	90% Confidence Upper Bound
College	NA	NA	NA	NA	NA	NA
Elem./Secondary Schools	10	121	1,632	12%	1,433	1,831
Grocery/Supermarket	15	321	4,660	11%	4,133	5,187
Health	40	123	3,213	6%	3,011	3,415
Hospital	NA	NA	NA	NA	NA	NA
Hotel/Motel – Common	NA	NA	NA	NA	NA	NA
Hotel/Motel – Guest Rooms	NA	NA	NA	NA	NA	NA
Mfg	40	188	2,980	10%	2,670	3,290
Office	132	88	2,567	6%	2,422	2,712
Other/Misc.	70	128	1,797	12%	1,586	2,008
Restaurant	25	299	3,613	14%	3,120	4,106
Retail	195	69	2,829	4%	2,716	2,942
Warehouse	49	138	2,316	10%	2,088	2,544

As with linear HOU, precision levels for linear CFs generally do not exceed 15%, with schools being the one exception at 22%.[7] This is expected as the peak periods occur after most classes have ended and after-school activities will vary significantly from one facility to another.

Precision levels for CFL HOU and CFs are also generally less than 15%, except for schools, manufacturing, and warehouses, which had precisions levels as high as 32%.

Itron is not aware of any other recent nonresidential lighting studies that have developed estimates of HOU by building type approaching these levels of statistical confidence and precision. The majority of studies reviewed do not contain estimates of precision or confidence levels at the building type and, in many cases, even at the sector level.

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6 The category "4 P.M. to 5 P.M." was chosen to represent "5 P.M." because it is considered the most representative of a peak load situation with the most lights still typically on. Many businesses begin to close at 5 P.M. and, for these businesses, a significant portion of lights are turned off between 5 P.M. and 6 P.M. Indoor nonresidential lighting load shapes are typically fairly stable in the late afternoon up until 5 P.M., but can often times exhibit a sharp decline between 5 P.M. and 6 P.M. Therefore, the hour between 4 P.M. and 5 P.M. was more representative of lighting usage at 5 P.M. than the 5 P.M. to 6 P.M. hour.

7 Confidence and precision levels for CFL HOU, and linear and CFL CFs are available from authors upon request.

Supplemented with the Database for Energy Efficiency Resources

Itron was able to use the California Lighting Study to develop statistically significant HOU and CF values for CFLs in 10 building types and linear fluorescents lamps in nine building types. For building categories in which the California Lighting Study samples were too small to provide reliable HOU estimates (colleges, hospitals, grocery stores and lodging), Itron supplemented its recommendations with values from the California DEER.

Itron considered recommending DEER values for all building types. DEER values are well documented and cover a wide range of building types. However, DEER values are based on building simulations rather than actual lighting logger data. Consequently, there was no way to adjust DEER CF values to be consistent with Maryland peak definitions because DEER 8760 results were not available.

Recommended Annual HOU and CF Values

This section summarizes the commercial lighting HOU and CF values that Itron recommended be used for the evaluation of the EmPOWER Maryland commercial lighting programs. Itron provided two sets of recommendations. The first and most comprehensive set of recommendations is by lighting group—linear fluorescent and CFLs—for all building types (Table 4), but does not distinguish between program delivery types. The second set of recommendations is limited to only four building types, but does distinguish between two program delivery types: direct install and prescriptive rebate (Table 5). Subsequent sections describe the methods and justifications for these recommendations

Recommended HOU and CFs by Lighting Group

Table 4 provides recommended annual HOU and CF values for CFLs and/or linear fluorescent lighting for the 13 nonresidential building types used in California and Maryland. The linear lighting values include both linear and high bay (i.e., 15 feet or more above the floor) lighting groups and are based on HOU and CF values from direct install and prescriptive rebate programs combined. For the CFL values, the logger data from both the upstream and downstream programs are combined.

Table 4 also provides estimates of CFs for the two peak period definitions, which can be used to transform estimates of kWh energy savings into peak demand savings. With the exception of CFLs in warehouses, the two definitions results in CFs that differ by ten percent or less.

Table 4: Recommended Values for Annual Hours of Use and Coincidence Factors

Building Type	Linear Lighting			Compact Fluorescent Lamps		
	HOU	CFpjm	CFemp	HOU	CFpjm	CFemp
College	***2,348***	***0.76***	***0.76***	***2,395***	***0.76***	***0.76***
Schools	1,632	0.31	0.28	1,670	0.41	0.44
Grocery/Supermarket	4,660	0.87	0.87	***3,879***	***0.87***	***0.87***
Health	3,213	0.73	0.76	1,888	0.43	0.43
Hospital	***5,182***	***0.80***	***0.80***	***4,081***	***0.80***	***0.80***
Lodging – Common Area	***7,884***	***0.90***	***0.90***	3,984	0.43	0.43
Lodging – Guest Rooms	***914***	***0.09***	***0.09***	766	0.09	0.09
Manufacturing	2,980	0.57	0.53	1,268	0.34	0.30
Office	2,567	0.61	0.60	2,478	0.43	0.45
Other/Misc.	1,797	0.34	0.32	1,871	0.33	0.34
Restaurant	3,613	0.65	0.67	3,765	0.62	0.62
Retail	2,829	0.73	0.76	3,043	0.60	0.61
Warehouse	2,316	0.54	0.55	2,063	0.58	0.69

Note: Bold, italicized values are from DEER.

Note that some of the values in Table 4 are derived from DEER. With the data from the California Lighting Study, Itron was only able to develop statistically significant HOU and CF values for CFLs in 10 building types and for linear fluorescent lamps in nine building types. For building categories in which the California Lighting Study samples were too small to provide reliable HOU estimates (colleges, hospitals, grocery stores and lodging), Itron used values from DEER. These values should be considered interim placeholders and should be updated with logger data results when and if they become available for Maryland.

Itron considered leaving the low precision values blank. However, the DEER values are relatively well documented (compared to other sources), cover a wide range of building types, contained both HOU and CF values, and compared favorably with the values derived from the California Lighting Study. Ideally, DEER CF values would have been adjusted to reflect the Maryland peak demand definitions, but the DEER CFs were used as-is for traceability/transparency because the CFs are not likely to vary much and DEER hourly data were not readily available. The DEER values are intended to be placeholders until actual lighting logger or other data from Maryland can be obtained.

Limited HOU/CF Recommendations for Linear Fluorescent Lighting by Program Delivery Type

The California Lighting Study samples sizes were not large enough to produce statistically reliable results simultaneously for all building types, lighting groups, and program delivery types. However, for the linear fluorescent lighting group and four building types—offices, retail, manufacturing, warehouses—the California Lighting Study sample sizes were sufficient to develop separate HOU values for direct install programs and prescriptive programs. These limited results are for users interested in distinguishing between the two program delivery types.

The HOU for the linear lighting prescriptive programs tends to be significantly higher than for linear lighting direct install customers. For example, the prescriptive program HOU for manufacturing is approximately two-thirds higher than the direct install HOU and the prescriptive office HOU is half again larger than the HOU for direct install program participants.

In large part, the difference in HOU between direct install and prescriptive programs is due to the different size of the participant facilities. Direct install programs are generally associated with smaller facilities. More than 90% of participants in the California direct install programs had a maximum demand less than 60 kW. Prescriptive programs tend to be distributed more evenly among small and large facilities. Roughly two-thirds of the California program participants had maximum demand greater than 60 kW.

If Maryland stakeholders so choose, the values in Table 5 could be applied to direct install and/or prescriptive programs instead of using the values in Table 1 separately. For example, the direct install HOU values could be applied to Baltimore Gas & Electricity's Small Business Lighting Solutions Program.

Table 5: Linear Lighting HOU by Program Type

Building Type	Combined	Direct Install	Prescriptive
Manufacturing	2,980	2,001	3,302
Office	2,567	2,047	3,110
Other/Misc.	1,797	1,669	2,063
Retail	2,829	2,692	3,330
Warehouse	2,316	1,915	2,598

Comparisons of HOU and CF Values from Other Sources

This section compares the HOU and CFs gathered from various sources and discusses possible reasons for the variation. A comparison of the HOU values for linear fluorescents is presented in Table 6 and for CFLs in Table 7. The six sources used for the analysis are as follows.

- **California Lighting Study.** Values derived by Itron for Maryland from the California Lighting Study – Small Commercial Contract Group Direct Impact Evaluation Report prepared by Itron for the California Public Utilities Commission Energy Division, February 9, 2010.
- **DEER, the Database for Energy Efficiency Resources.** The 2008 version is available from the website of the California Public Utilities Commission at http://www.deeresources.com/.
- **The Mid-Atlantic TRM.** Northeast Energy Efficiency Partnerships, Mid-Atlantic Technical Reference Manual, Version 1.0, submitted by Vermont Energy Investment Corporation, May 20, 2010. This is the TRM currently used for Maryland.
- **The Pennsylvania TRM.** Technical Reference Manual for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards, June 2010. Another version is under development but not yet available.
- **The Ohio TRM.** For Ohio, Itron references two documents: the Draft 2010 Ohio TRM submitted by Vermont Energy Investment Corporation and the TRM for Ohio Senate Bill 221 Energy Efficiency and Conservation Program submitted by Ohio Electric Utilities, October 2009. The Draft 2010 Ohio TRM includes only a select set of measures. For measures that are not in the Draft 2010 Ohio TRM, Itron refers to the TRM for Ohio Senate Bill 221.
- **New England Lighting Study.** RLW Analytics, Coincidence Factor Study: Residential and Commercial Industrial Lighting Measures, prepared for New England State Program Working Group, Spring 2007.

Variation/Range in HOU and CF Values

HOU and CF values vary widely across the reference sources considered for this study. As shown in Table 6, linear lighting HOU values for warehouses, hospitals, college, hotel/motel, and other/miscellaneous building types all vary by 50% or more of the average value. Linear HOU values vary by 100% or more of the average value for hotel/motel common areas and guest rooms, in large part due to some TRMs providing a single value for these two building types. As shown by the California Lighting Study, and as would be expected, there is a significant difference in HOU for hotel guest rooms versus common areas.

Table 6: Range of Linear Fluorescent Lighting HOU Values from All Reference Sources

Building Type	Average	Low	High	Range	Range % of Average
College	3,779	2,348	5,010	2,662	72%
Elementary/Secondary Schools	2,101	1,632	2,302	670	33%
Grocery/Supermarket	5,347	4,612	5,824	1,212	24%
Health	3,881	3,213	4,308	1,095	29%
Hospital	5,104	3,677	6,588	2,911	58%
Hotel/Motel – Common	5,431	2,697	8,736	6,039	107%
Hotel/Motel – Guest Rooms	2,518	914	3,356	2,442	120%
Manufacturing	3,822	2,980	4,745	1,765	46%
Office	3,111	2,567	3,526	959	32%
Other/Misc.	2,750	1,797	3,672	1,875	73%
Restaurant	4,468	3,613	5,278	1,665	37%
Retail	3,890	2,829	4,226	1,397	39%
Warehouse	3,185	2,316	3,900	1,584	50%

Likewise, as shown in Table 7, for CFL HOU the range as a percent of the average values exceeds 50% for all but two building types.

Table 7: Range of CFL HOU Values from All Reference Sources

Building Type	Average	Low	High	Range	Range % of Average
College	3,486	2,395	4,204	1,809	52%
Elementary/Secondary Schools	2,355	1,670	3,500	1,830	78%
Grocery/Supermarket	5,060	3,500	6,552	3,052	60%
Health	3,562	1,888	4,481	2,593	73%
Hospital	4,677	3,500	6,588	3,088	66%
Hotel/Motel – Common	5,013	3,356	8,736	5,380	107%
Hotel/Motel – Guest Rooms	2,360	766	4,480	3,714	157%
Manufacturing	3,376	1,268	4,745	3,477	103%
Office	3,168	2,478	3,715	1,237	39%
Other/Misc.	3,074	1,871	3,672	1,801	59%
Restaurant	4,384	3,500	5,278	1,778	41%
Retail	4,056	3,043	5,367	2,324	57%
Warehouse	3,255	2,063	3,900	1,837	56%

Itron's Recommended Values are at the Low End of the Range from All Sources

Itron's recommended values are generally at the lower end of the range of HOU and CF estimates from other sources. For linear lighting HOU, Itron's recommended values for 10 of the 13 building types are the lowest of all the sources. For CFL HOU, Itron's recommended values are lowest for nine of the 13 building types. A similar pattern is true for CFs. Lower values translate directly into lower estimates of savings for more efficient lighting systems. However, the California Lighting Study based values were derived from lighting logger data in actual buildings and, as such, should represent the *best estimate of actual expected operation*.

Possible Reasons for Variation Among Sources

Any number of factors could cause results from the California Lighting Study, or any of the other studies for that matter, not to be directly transferrable to the EmPOWER Maryland lighting programs. The factors considered include the following.

- Energy efficient lighting saturation levels are likely to be higher in California compared to Maryland since California utilities have promoted efficient lighting far more aggressively than Maryland utilities over the last decade. It is not entirely clear whether higher saturation results in lower or high HOU, however. On the one hand, the "marginal socket" – i.e., where the program lamp or fixture will be installed – is likely to be in higher use areas in Maryland than California, where high use areas are more likely to already have efficient lamps and fixtures installed.
- Slower economic activity over the last couple of years could drive lower HOU and CF values in the California Lighting Study (published in 2009) relative to the other data sources reviewed, all of which are based on pre-recession economic activity.
- There are different distributions in the share of lighting activity areas within individual building types. For example, the EmPOWER Maryland programs might disproportionately target small or large utility customers (as defined by kW) relative to programs examined by other studies.
- There are differences in lighting quality. For example, the brighter light from new T5 lamps allows other task lighting to be dimmed or not used in adjacent areas. Lighting HOU, especially for CFLs, could thus be lower in areas such as California where T5s are likely more prevalent than in Maryland.
- The different studies reviewed define building types differently. This is a perennial issue with these types of analyses.
- There are differences in the mix of small versus large buildings used in the analysis samples. Without underlying data from other studies, there is no way to compare the mix of small and large buildings in the other sources to the California Lighting Study or to the Maryland nonresidential lighting program participants.
- There are different peak period definitions. Itron has provided CFs for PJM and EmPOWER peak definitions, but other studies used slightly different definitions of peak demand and CF.
- Lighting usage definitions are unclear. Some studies use estimates of building hours of operation as a surrogate for lighting system use. Some use self-reports of lighting system operation hours and some use estimates of equivalent full load hours from building simulation models (HOU adjusted for dimming). It is not always clear that these HOU terms are being used consistently or accurately. Itron's recommended values are for HOU for lighting systems based on metered on and off times.
- Some lighting surveys include HOU estimates for program participants only, while others include nonparticipants. The California Lighting Study is a participant study and only fixtures or lamps incentivized by the utility energy efficiency programs were logged. Program participants may be predisposed to a "conservation ethic" and, as such, may use their lighting systems less

than the general population both before and after the lighting system retrofits.

- Analytical quality and underlying assumptions and methods vary from study to study.

Since most of the sources reviewed do not fully document how the HOU and CF assumptions were derived, Itron is unable to attribute differences in results to these various factors. An advantage of using the California Lighting Study results is that the methods used to develop these estimates are not only transparent, but the result of eight months of vigorous review by stakeholders in California.

After balancing all of the factors discussed above, Itron concluded that the values used in Maryland should rely primarily on the data collected in the California Lighting Study. This conclusion was reaffirmed and accepted by the Maryland utilities and stakeholders and the recommended values were incorporated into the latest version of the Mid-Atlantic TRM.

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