
DNV·GL

MA C&I PROJECT 86

Lighting Hours of Use Study

Massachusetts Program Administrators and Energy Efficiency
Advisory Council

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1 INTRODUCTION

This document presents the results of the “Quick Hits” C&I Lighting Hours of Use Study (C&I Lighting HOU Study). The primary objective of this project was to develop building level annual hours of use estimates for estimating savings for the upstream lighting program offering.

According to conversations with Massachusetts Program Administrator (PA) staff, the upstream subcommittee is considering moving away from product specific annual HOU estimates to building level HOU estimates for several reasons, including improved customer targeting, alignment with commercial lighting best practices (NREL)¹, and in response to recent evaluation findings and Energy Efficiency Advisory Council (EEAC) feedback to leverage upstream leads to get deeper energy efficiency savings.

This study made use of site level lighting fixture savings results from all of the C&I lighting impact evaluations conducted in MA since 2010. DNV GL performed a thorough review of completed impact evaluation projects to identify known sources of lighting fixture savings profiles. In total, 458 unique sites have been metered and evaluated by the DNV GL team during this period. These impact evaluations include:

- P12 – 2010 Custom Lighting (45 sites)
- P12 – 2010 Prescriptive Lighting (57 sites, including 12 months of metering)
- P17 – 2012 Upstream Lighting (81 sites)
- P58 – 2016 Upstream Lighting (170 sites)
- P69 – 2016 Small Business Lighting (105 sites)

There are two study caveats:

1. All of the hours of use estimates are based on metered profiles (with the exception of exterior lighting on timers), however only those from the P12 Prescriptive Lighting evaluation are based on a full year of metered data. For all other sites, the metering period was typically 8-12 weeks, and was extrapolated to the rest of the year using knowledge of the individual building annual operating schedules as reported by each customer.
2. The profiles have been selected opportunistically, as available from past study efforts, and therefore cannot be guaranteed to be representative of a population. The profiles were examined for anomalies which may have warranted exclusion or special handling in the aggregated result.

1.1 Study objectives

The objective of this study is to develop building level lighting annual hours of use estimates that will be used by the MA PAs to estimate savings for the upstream lighting program offering. The results of this study are expected to be integrated into the MA PAs’ 2019-2021 three-year evaluation plan.

¹ Dakers Gowans, Left Fork Energy & Chad Telarico, DNV GL, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures Chapter 2: Commercial and Industrial Lighting Evaluation Protocol, National Renewable Energy Laboratory (NREL), p. 21, <https://www.nrel.gov/docs/fy17osti/68558.pdf>

2 SUMMARY OF APPROACH

The following summarizes the approach the evaluation team used for developing the building level lighting annual hours of use estimates. Given that this was a “Quick Hits” study and the compressed timeline for completion, there was one task associated with this work.

2.1 Task 1: Develop HOU estimates

As part of this scoping effort, the DNV GL team collected all of the site level savings spreadsheets conducted by evaluators in MA since 2010. In total, we identified 458 unique sites across five C&I lighting evaluations. Table 2-1 details the number of sites identified as part of this planning effort to be included in the analysis.

Table 2-1. Completed MA C&I lighting studies

MA Study	Program Year	Number of Sites	Typical Metering Length
P12 Custom Lighting	2010	45	8-12 weeks
P12 Prescriptive Lighting	2010	57	52 weeks
P17 Upstream Lighting	2012	81	8-12 weeks
P58 Upstream Lighting	2016	170	8-12 weeks
P68 Small Business Lighting	2016	105	8-12 weeks
Total		458	

As part of the preliminary lighting site identification effort, the team referenced source folders and server locations for all the identified projects. Next, the DNV GL team extracted copies of all applicable site spreadsheets that were used in the analysis. We reviewed all sites and processed them into a common format for use in the analysis. The format included the following information for each site:

- PA sponsor
- Study name
- Site ID
- Program year studied
- Year of metering
- Building type
- Connected kW savings (fixtures only)
- Annual kWh savings (fixtures only)
- Annual lighting hours of use

2.1.1 Annual lighting hours of use

Annual hours of use for each site were calculated by dividing the total site annual kWh savings by the site connected kW savings to ensure a consistent approach across sites. Only fixture savings were used in this calculation, since fixture savings are derived from the lighting operating hours. Lighting controls savings were not factored into the calculation of annual operating hours.

2.1.2 Building type

The site level HOU estimates were aggregated by building type according to those listed in Table 2-2. This list was provided by the upstream subcommittee based on three different sources, including their two upstream vendors and CBECS.

Table 2-2. Building type and description

Building Type	Description	Includes
College & University	Buildings used for academic or technical classroom instruction such as classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not classroom are included in the category relating to their use. For example, administration buildings are part of "Office," dormitories are "Lodging," and libraries are "Other."	College or university, junior or community college
Government Building	Buildings used for general office space, professional office, or administrative offices. Does not include police or fire stations or courts, which are included in the "Other" building type.	Federal, state, or local government office, city hall, city center.
Grocery / Food Sales	Buildings used for retail or wholesale of food.	Grocery store or food market, gas station with convenience store, convenience store
Hospital	Buildings used as diagnostic and treatment facilities for inpatient care.	Hospital, inpatient rehabilitation, nursing homes
Industrial / Manufacturing	Comprises facilities where mechanical or chemical transformations of materials or substances into new products take place. Range from steel mills, to small farms, to companies assembling electronic components.	Plants, factories or mills.
K-12 School	Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools.	Elementary & High schools, preschool or daycare, adult education, care or vocational training, religious education
Lodging	Buildings used to offer multiple accommodations for short-term or long-term residents, including skilled nursing and other residential care buildings.	Motel or inn, hotel, dormitory, retirement home, nursing home, assisted living

Building Type	Description	Includes
Medical Office	Buildings used as diagnostic and treatment facilities for outpatient care. Medical offices are included here if they use any type of diagnostic medical equipment (if they do not, they are categorized as an office building).	Medical office, clinic or other outpatient health care, veterinarian
Multifamily	Residential dwellings consisting of 5 or more individual living units.	
Office Building	Buildings used for general office space, professional office, or administrative offices excluding government. Medical offices are included here if they do not use any type of diagnostic medical equipment (if they do, they are categorized as an outpatient health care building).	Administrative or professional office, bank or other financial institution, mixed-use office, sales office, call center.
Restaurant / Food Service	Buildings used for preparation and sale of food and beverages for consumption.	Fast food, restaurant or cafeteria, bar, coffee, bagel or doughnut shop, ice cream or frozen yogurt shop
Retail	Buildings used for the sale and display of goods other than food.	Retail store, beer, wine or liquor store, auto dealership or showroom, enclosed mall, strip shopping center
Warehouse and storage	Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage).	Refrigerated warehouse, non-refrigerated warehouse, distribution or shipping center.
Other	All other non-residential buildings not otherwise defined in this list.	Includes a wide variety of buildings including: recreational and entertainment facilities such as health clubs, ice rinks, museums, theaters, casinos; service oriented facilities such as auto repair shops, dry cleaners, car washes, post offices, libraries, etc.; religious facilities such as churches, mosques, synagogues

3 RESULTS

Table 3-1 presents the results of this analysis as well as the absolute and relative precision estimates for each building type. All precisions were calculated at the 90% confidence interval. The final list of buildings used in the analysis was pared down from the 458 that were initially identified in the scoping stage down to 406 for various reasons. These mostly included combining unique project analyses that were completed at the same building into one and sites that only included incentivized lighting controls.

Table 3-1. Building type hours of use

Building Type		Count of Buildings	Hours of Use	Standard Error	Absolute Precision (t-value)	Relative Precision (t-value)
College & University		19	4,839	892	1,546	±32.0%
Grocery/Food Sales		28	5,468	252	430	±7.9%
Hospital		15	5,413	545	959	±17.7%
Industrial/Manufacturing		21	4,988	494	852	±17.1%
K-12 School		37	2,788	197	332	±11.9%
Lodging		34	4,026	511	865	±21.5%
Medical Office		10	3,673	134	245	±6.7%
Office Building		64	4,181	262	438	±10.5%
Other		105	4,336	373	619	±14.3%
Restaurant/Food Service		19	5,018	707	1,226	±24.4%
Retail		44	4,939	341	573	±11.6%
Warehouse and storage		10	6,512	634	1,163	±17.9%
Overall		406	4,416	30	50	±1.1%

3.1 Key Findings

This analysis relied on previously collected data from MA C&I lighting impact evaluations completed between 2010 and 2018. This resulted in some limitations in the ability to drill down into all of the requested building types. For example, results for Multifamily and Other-Automotive² were poor due to the limited number of buildings available and the variation within each category as shown in Table 3-2. Due to this, both buildings were included in “Other” in the table above.

² Other-Automotive was separated out from “Other” in Table 2-2 as the PAs had a requested these results be looked at separately. However, after reviewing the resulting precision, it was decided to continue to include these with “Other.”

Table 3-2. Multifamily and Other-Automotive results

Building Type		Count of Buildings	Hours of Use	Standard Error	Absolute Precision (t-value)	Relative Precision (t-value)
Multifamily		8	4,545	1,425	2,699	59.4%
Other-Automotive		11	2,021	817	1,481	73.3%

Similarly, there were only two Government Buildings in the dataset. It was assumed that Government Buildings were similar enough to be combined with Office Buildings for these purposes.

In all other cases, the relative precisions were considered to be reasonable enough to use the individual building type results for estimating lighting savings going forward.

4 CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions, recommendations, and opportunities for future research.

4.1 Conclusions

- Hours of use estimates were generated for twelve different building types based on data collected in MA beginning in 2010.
- Building type results had relative precisions ranging from $\pm 7\%$ for Medical Offices to $\pm 32\%$ for College and Universities.

4.2 Recommendations

1. For lighting savings estimation, use the building specific hours of use provided in Table 3-1.
2. For Government Buildings, use the Office Building hours from Table 3-1.
3. For Police/Fire Stations and Court Buildings, use the "Other" building type from Table 3-1.
4. For Multifamily and Other-Automotive, use the "Other" building type from Table 3-1.
5. If a building type is unknown, use the "Overall" result from Table 3-1, which represents the average operating hours of all building types combined.

4.3 Considerations

1. This study was developed for the purpose of generating building specific hours of use values for estimating savings for upstream lighting purchases. However, the data used in this study were sourced from both upstream and downstream lighting program impact evaluations, which would allow these results to be applied more broadly to other non-upstream lighting projects. For traditional downstream lighting projects, the MA PAs typically rely on site-specific hours to estimate gross energy savings. These are usually provided by the vendor involved in the project or directly from the customer themselves. If there are cases where it may not be viable to generate reasonable site-specific hours of use estimates, the PAs could consider using the results from this study as an alternate solution.

4.4 Future research

1. Consider expanding this analysis to include lighting profiles from the NEEP C&I Lighting Load Shape Project.³ Although this study was designed to use C&I lighting impact evaluation results from MA specific studies completed since 2010, the NEEP study included logger data from over 750 buildings, many of which were in MA. Though the source data is older, the additional building profiles could improve some of the building specific precision estimates when combined with the results of this study.
2. An alternative approach would be to consider updating this analysis as future C&I lighting impact evaluations are completed. Currently, a large MA Custom Electric study is being conducted, which includes 46 lighting sites across various building types that could be integrated into this analysis in early 2019.

³ KEMA, Inc. C&I Lighting Load Shape Project Final Report Prepared for the Regional Evaluation, Measurement and Verification Forum facilitated by Northeast Energy Efficiency Partnerships (NEEP). July 19, 2011. <https://neep.org/commercial-lighting-load-shape-study-0>



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