EMI CONSULTING

# Michigan Statewide Commercial & Industrial Lighting Hours-of-Use Study

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FINAL REPORT




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# EXECUTIVE SUMMARY

This executive summary presents results for the Consumers Energy and DTE Energy Commercial & Industrial (C&I) Lighting Hours of Use Metering Study. This study was designed to collect, analyze, and report data of a representative sample of metered C&I lighting to inform the estimates of electric energy and demand impacts of Energy Opportunities (EO) program lighting measures. The main focus of this work was to determine lighting hours-of-use (HOU), which is an important "assumed" value in lighting energy and demand savings estimates. Current electric energy and demand savings calculations for the Michigan Energy Measures Database (MEMD) related to lighting measures assume 3,680 annual HOU and a peak coincidence factor of 0.90 for most non-high bay lighting measures based on secondary research conducted for the State of Wisconsin (4,160 HOU and 0.95 CF for high bay lighting).[1]

## Key Findings

The research team calculated the updated value for hours of use and the preliminary value for coincidence factor by combining metered observations during Wave 1 of this study with results from a similar study of lighting controls.[2] These metered observations were weighted by metered space and facility type and then adjusted for all facility types collected in a facility type incidence study that was part of this study.[3] These overall values, as well as the existing MEMD values, are presented in Table E-1.[4]

Table E- 1. Hours of Use and Coincidence Factor Values

| Variable | Current MEMD Value (a) | Calibrated Value (b) | Ratio (b)/(a) |
|---|---|---|---|
| Hours of Use | 3,680 | 2,744 | 0.755 |
| Coincidence Factor | 0.90 | 0.505 | 0.561 |

[a.] Current MEMD Value is based on the non-high bay estimates.

## Methodology

The research team determined preliminary lighting hours-of-use (HOU) and coincidence factors (CF) using metered lighting data from Wave 1 of this metering study and from the 2013

[1] PA Consulting and KEMA. 2010. *Focus on Energy Evaluation: Business Programs: Deemed Savings Manual V1.0*. March 22, 2010

[2] The present study includes two waves. The Wave 1 was completed in winter and spring 2014; Wave 2 will continue through the summer.

[3] The facility type incidence study, described below, was collection of facility type from each contact dialed during recruiting for the study; 886 facilities responded.

[4] Facilities with significantly different operating hours than those described in this report may be more appropriately served through a custom energy savings approach to account for their greater variation in HOU and CF.

Lighting Controls Study. The team installed lighting loggers to measure lighting use over a metering period averaging 42 days. Based on the lighting use during the metered period, the team estimated weekday and weekend usage and modeled annual hours based on those usage estimates, as well as observed holidays or other facility closures. The research team also modeled preliminary CF estimates based on lighting use for the hours between 3PM and 6PM in the summer.

The research team aggregated the logger level estimates to the space-type level (such as, "restrooms") for each facility based on the installed wattages in each space. We then aggregated the facility estimates to an overall estimate for a facility type based on the installed lighting wattage in each facility. Finally, we aggregated the facility-type estimates to the overall estimate based on the distribution of facility types in Michigan.

# 1. Introduction

This report presents results for the Commercial Lighting Hours-of-Use Study conducted by EMI Consulting for Consumers Energy and DTE Energy in 2013 and 2014. The report begins by providing some background information, then describes study methodology, and concludes with the study results.

## 1.1 Background and Study Objectives

The overarching objective of this study was to collect, analyze, summarize, and report data to calibrate the hours-of-use (HOU) and peak coincidence factors (CFs) for commercial & industrial (C&I) lighting to inform potential adjustments to the Michigan Energy Measures Database (MEMD). This study is important to the success of the Energy Optimization (EO) Plans as C&I lighting measures contribute approximately 75% to the expected electric energy savings of Consumers Energy and DTE Energy programs each year.[5] The study provides the MPSC and EO Program administrators with accurate, up-to-date data for use in determining energy savings, which in turn will provide more accurate energy savings estimates.

The MEMD was developed by Morgan Marketing Partners (MMP) as the basis for the initial energy efficiency potential estimates in the EO Plan. Michigan's EO Program administrators now use the MEMD to develop and update their EO program plans, as well to calculate the gross energy and demand savings achieved in each program year for included measures. Among other things, the MEMD specifies the per-unit energy (kWh, MCF) and demand (kW) impact estimates of each measure in the database. The per-unit impacts of MEMD measures are stipulated, or "deemed," until there is consensus among parties that a revision to the MEMD is warranted.[6]

The purpose of this study is to collect reliable data on C&I lighting HOU and CFs for the State of Michigan to validate and/or calibrate the MEMD to more accurately reflect local operating conditions and provide a more granular approach for estimating HOU at C&I facilities where possible (i.e., provide several HOU estimates for use at varying facility or space types). This study focuses on C&I HOU and CFs, as these are the two values used in the energy and demand savings calculations that are currently assumed. Current electric energy and demand savings calculations for the MEMD related to lighting measures assume 3,680 annual HOU and a peak coincidence factor of 0.90 for most non-high bay lighting measures based on secondary research conducted for the State of Wisconsin (4,160 HOU and 0.95 CF for high bay lighting).[7]

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[5] Subpart B of PA 295 requires providers of electric or natural gas service to establish Energy Optimization (EO) programs for their customers.

[6] "*Parties*" refers to the collective membership of either the Program Design and Implementation Collaborative or the Evaluation Collaborative, under the auspices of the Michigan Public Service Commission.

[7] PA Consulting and KEMA. 2010. *Focus on Energy Evaluation: Business Programs: Deemed Savings Manual V1.0*. March 22, 2010

The Wisconsin report relied exclusively on secondary data; none of the included studies represented any Midwestern states or were completed after 2006.[8]

Data collection for Wave 1 of this metering study consisted of two main parts: (1) an on-site field inspection report of sampled C&I facilities, and (2) metering of lighting to determine HOU and inform CFs. In addition, an incidence study, completed during recruitment for participating facilities, collected information on the distribution of facility types across the C&I customer population.

As detailed in the remainder of this report, the research team analyzed this data to produce estimates of the following for commercial lighting in Michigan:

- Lighting HOU
- Peak coincidence factors
- Type, number, and wattage of lighting equipment
- Heating and cooling equipment specifications and usage

[8] The Wisconsin report synthesized results from six previous studies. Four of these were conducted in California; one in Massachusetts and Maryland; one was a national DOE study.

# 2. Methodology

This section briefly describes the research methods used to conduct this study, including research design, sample design, recruitment and field protocols, QA/QC, and analysis methods.

## 2.1 Research Design

For this study the research team used data collected from facilities to estimate hours of use at the facility- and space-type level. Data was collected during two waves of metering. The first wave, from January to April 2014, gathered preliminary hours-of-use data but did not include any peak period measurements. The second wave, from April to August 2014, will include measurements from the peak demand period and will be used to refine hours-of-use and coincidence factors at the facility- and space-type level. In addition, we also used data collected during metering for the 2013 Lighting Controls Study for this study.

The research team recruited participants for on-site metering from randomly selected Consumers Energy and DTE Energy customer samples. We collected data on lighting hours-of-use, facility operating hours, type and wattage of fixtures, and peak coincidence factors for different facility types, as summarized in Table 2-1.

Table 2-1. Primary Data Collected from Study Participants

| Data Type | Data Collection Method [a] |
|---|---|
| Lighting Hours-of-Use | Metering |
| Peak Coincidence Factors | Metering |
| Facility Operating Hours | Field Technician Report |
| Inventory of Space Types | Field Technician Report |
| Type, Number, and Nominal Wattage of Lighting Equipment | Field Technician Report |
| Heating and Cooling Equipment Specifications and Usage | Field Technician Report |
| Facility Distribution | Incidence Study |

a. Timing notes: The Incidence Study was conducted in conjunction with recruitment for the metering study. The Field Technician Report is based on data collected during the on-site visits. The metering data are from meters installed during the on-site visits.

## 2.2 Sample Design

The research team developed the sample frame for this study from comprehensive C&I customer population files provided by Consumers Energy and DTE Energy.

Overall, 180 C&I facilities were randomly selected from the sample frame and recruited to participate in the two waves of lighting metering for this study. With these 180 facilities, the sample included 3,248 inventoried spaces and 1,360 metered observations of spaces.[9]

Table 2-2. Participating Facilities by Facility Type and Utility

| Facility Type | CE | | DTE | | Total | |
|---|---|---|---|---|---|---|
| | **Count** | % | **Count** | % | **Count** | % |
| Apartments | 8 | 8% | 1 | 1% | 9 | 5% |
| Assembly | 7 | 7% | 3 | 4% | 10 | 6% |
| Industry | 10 | 9% | 2 | 3% | 12 | 7% |
| Lodging | 1 | 1% | 0 | 0% | 1 | 1% |
| Medical | 5 | 5% | 4 | 5% | 9 | 5% |
| Office | 19 | 18% | 12 | 16% | 31 | 17% |
| Other | 10 | 9% | 7 | 9% | 17 | 9% |
| Restaurant | 6 | 6% | 3 | 4% | 9 | 5% |
| Retail | 29 | 27% | 39 | 53% | 68 | 38% |
| School (K-12) | 5 | 5% | 1 | 1% | 6 | 3% |
| Warehouse | 6 | 6% | 2 | 3% | 8 | 4% |
| **Total** | **106** | **100%** | **74** | **100%** | **180** | **100%** |

While these facilities are intended to be representative of the C&I population in Michigan, participants must self-select into the study through recruitment. Therefore, there is a possibility of sample bias. The most likely places for sample bias are:

- **Industry**: The distribution of sampled industrial facilities may not align with the Michigan population of industrial customers. Out of 12 industrial facilities that agreed to participate in this study, all were light industry and only one was a multiple shift facility. Without additional data from "heavy" industry sites, we were unable to determine the degree of this possible bias or correct for it. Recent program evaluations in Michigan have shown an average HOU for multiple shift industrial sites that is more than double what was observed in this study.[10] Given this high degree of variation among industrial facilities, we recommend that these facilities continue to complete projects based on custom incentives.

[9] There were an average of 5.9 different space types per facility.
[10] Conversation with Navigant Consulting regarding custom program evaluation results.

- **Office**: The distribution of sampled office facilities may not match the distribution of office spaces in Michigan. The 31 office facilities in the study had an average size of just over 4,000 square feet. This is substantially below the national average for office spaces. However, our analysis of the available data on office space in Michigan indicates that our sample is likely representative of the population of offices in the state. This report describes this analysis in more detail in the Descriptive Statistics section.

## 2.3 Study Recruitment

The research team contacted customers by telephone to recruit them for this study. Customers were randomly contacted from the sample frames until the quota for each utility stratum in the sample design was filled. We attempted five contacts with each customer before the customer was dropped from the sample frame.

Recruiting for this hours-of-use study was broken up into two parts: winter and summer. The research team recruited 180 metering participants for the winter metering period. Most of these participants chose to remain in the study group for summer metering; two chose not to remain. The team recruited an additional two sites for summer metering.

The scripts for the recruitment telephone calls are included in the study protocols manual (separate document). The scripts were designed to: (1) identify the most appropriate individual at the customer site, (2) determine eligibility for the study, (3) confirm contact information and facility address, (3) collect information on facility type, and (4) schedule an on-site visit for equipment inventory and logger installation.

The research team collected information on facility type from non-participants (customers who were contacted and declined to participate) in order to inform an incidence study on facility type. One significant unknown among the Michigan C&I population is the distribution of facility types; without facility type distributions, it is impossible to estimate the actual precision of the study results. To gain better insight into the actual distribution of facility types throughout the Consumers Energy and DTE Energy service areas, we embedded this incidence study within the recruitment effort.

The on-site visits were typically scheduled into two- to four-hour time slots depending on facility size, and the recruiter made every possible effort to work with the customer to schedule a convenient time for the visit. In some circumstances, this required adapting time slots or scheduling a customer across multiple time slots. The recruiter also attempted to schedule on-site visits to maximize the number of sites visited by the field technicians each day.

## 2.4 Field Protocols

The initial on-site visit was comprised of a brief survey, a comprehensive facility lighting and space type inventory, and the installation of the logging equipment. The lighting inventory survey was used to determine the total number and types of lighting fixtures, usage categories, typical hours-of-use, and operating schedules for each space in the facility covered in the study.

The customer was interviewed in order to determine any fixture details that could not be inspected.

The field technician used the lighting and space type inventory to determine which lighting could have loggers installed. Spaces were randomly selected from the eligible lighting to be logged.

For this study, the field technicians used Hobo UX-90-002 and U12-012 loggers. The UX90-002 logger is a light on/off state logger that registers a change in state based on observed ambient light levels and a user-adjustable sensitivity level. The U12-012 logger is a light intensity (footcandle) logger. The U12-012 logger records the measured light level (footcandles) at a user-defined interval. The field technicians installed Hobo U12-012 loggers in locations that are expected to have a greater variance in ambient light level conditions, such as rooms with large windows or multiple independent light sources. Additionally, U12-012 loggers typically were installed in locations with dual-level lighting or dimming capability.

## 2.5 QA/QC

The evaluation team reviewed the logger, facility, and space for any missing data. Data were reviewed for completeness, consistency, and reasonableness. Ultimately, data from 93 of the 1,360 participant loggers were dropped because of "bad" logger data.

## 2.6 Analysis Methods

The research team computed descriptive statistics to describe the sample of facilities included in the study. For all computed results, we summarized the data at the space type (within facility types), facility type, as well as overall, using appropriate weighting. The weighting methods to estimate facility-type level results are described in Appendix A. Results are presented in terms of counts, percentages, means, and standard deviations.

The primary metrics analyzed are:

- Hours of Use
- Peak Coincidence Factor
- Lighting Equipment Inventory
- Heating and Cooling Equipment Specifications and Usage

### Hours of Use

Average annual HOU were calculated from metered data. Data from individual loggers was averaged across the week and weekend days for which the logger collected data, such that an annual HOU value is estimated for each logger/space. The team aggregated logger level estimates of annual HOU to the facility-type level. Average annual HOU are reported by facility type with a 90% confidence interval.

## Peak Coincidence Factor

The peak coincidence period for this study is defined as 3PM to 6PM on non-holiday weekdays during the three consecutive hottest days in July in accordance with the MEMD definition of peak for weather-sensitive measures. The peak coincidence factor is defined as the percentage of peak period that a light is on. For each logger, the peak coincident factor was computed as the average across all weekdays collected and adjusted based on reported facility closures.

It is important to emphasize that the first metering period for this study did not coincide with the utilities' peak period – this first wave occurred in the winter and spring, while peak period is in the summer. As such, in this report the research team is providing *preliminary* estimates of peak coincidence for the 2015 MEMD Update. For these preliminary estimates, the research team used the metered data to estimate peak coincidence. The approach for estimating peak coincidence involved two steps: (1) creating weekday and weekend profiles based on the metered data, and (2) calculating the coincidence factor (CF) based on the modeled *weekday* profile based on reported facility operation. These resulting modeled values were then aggregated to facility-type CFs. Preliminary CFs are reported by facility type with a 90% confidence interval.

The second metering period will occur during the summer peak period. Metering data from this period will coincide with the utilities' peak period. As such, the research team will provide an updated estimate of peak coincidence based on these data. We will develop profiles of lighting use by hour to identify the portion of C&I lighting that is in use during the summer peak period.

## Lighting Equipment Inventory

Research team field engineers inventoried the lighting equipment of Wave 1 participants through a comprehensive survey of each facility's type, number, and nominal wattage of installed lighting. Lighting equipment is tabulated and reported by space type.

## Heating and Cooling Equipment Specifications and Usage

This study collected information on the HVAC equipment of Wave 1 participants' facilities to begin to provide some insights for understanding interactive effects. HVAC equipment was not metered as part of this study, only observed. To-date, comprehensive information on the potential interactions of lighting and HVAC has not been conducted in Michigan. The information collected through this study is summarized by facility type.

## Incorporating Lighting Controls Study

Last year, this team conducted a metering study to determine the difference in lighting HOU and CFs for controlled and non-controlled lighting.[11] That metering study included HOU and

[11] Commercial Lighting Controls Metering Study. Presentation dated June 18, 2013. Retrieved from: http://www.dleg.state.mi.us/mpsc/electric/workgroups/progdesign/lcs_ce_2013_06_16.pdf

CF estimates for 3,224 spaces in School, Office, and Industrial Warehouse spaces. Each of the loggers from the lighting controls study are incorporated into the current analysis as described for Wave 1, above.

# 3. Detailed Results

The following section provides the detailed results of the research team's analysis. This includes three categories of results:

1. Results from lighting loggers installed during Wave 1 combined with results from the Lighting Controls Study,
2. Descriptive statistics for the sampled facilities and spaces in Wave 1, and,
3. Data on heating and cooling system types that were collected for the inventoried spaces during the on-site visits.

Descriptive statistics about the sampled facilities and spaces include the number of observations, the operating hours of the facilities, and the square footage of the facilities and spaces included in Wave 1 of the metering study. Hours-of-use and coincidence factor results from the Wave 1 loggers and Lighting Controls Study are presented by facility type.

## 3.1 Logger Results

This section documents the research team's analysis of the lighting logger data collection. The section presents hours-of-use and preliminary coincidence factors by facility type first, and then follows with an analysis of space type within facility type. All results in this section are weighted by wattage of metered space type and facility type.

### Facility Lighting Hours of Use

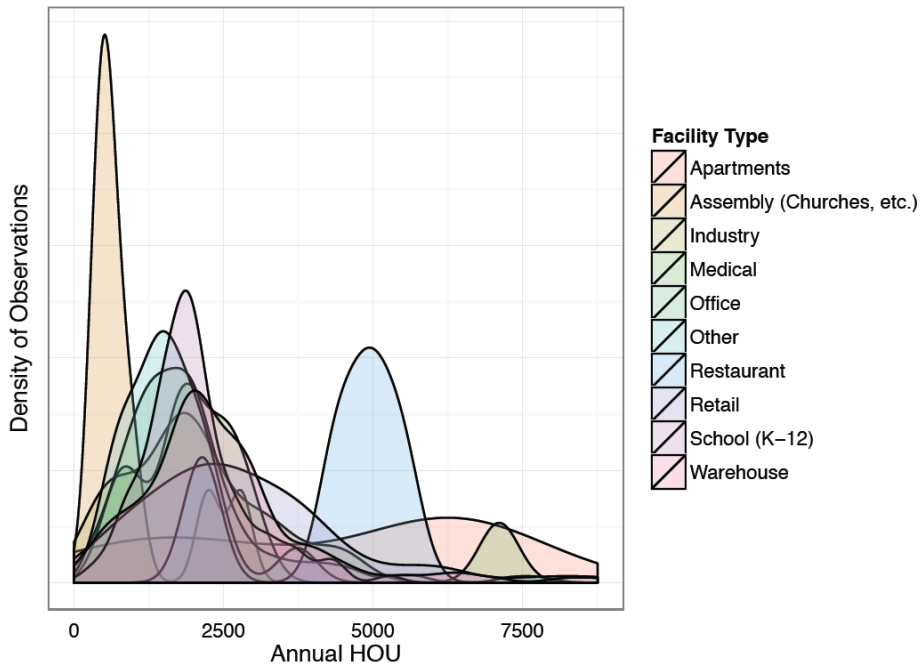
The research team summarized lighting hours-of-use (HOU) by facility type. We adjusted metered observations within each participating site to account for space type within a facility, using wattages of both metered and unmetered spaces as weights. Table 3-1 below shows the annual HOU and the relative precision for 90% confidence. Lighting HOU were aggregated to the weighted overall total based on the distribution of facility types in the incidence study. The weighted mean HOU for these C&I facilities based only on the lighting study (Wave 1) is 2775.8 hours per year, while the weighted mean from the lighting controls study is 2167.7 hours per year. Combined, these studies provide an estimate of 2743.7 hours per year, with 4,580 loggers covering 4,491 observed spaces.

Table 3-1. Hours-of-Use by Facility Type

| Facility Type | HOU | Std. Dev. | Loggers (n) | Relative Precision |
|---|---|---|---|---|
| Apartments | 5,184 | 2325 | 55 | 10% |
| Assembly (Churches, etc.) | 1,686 | 1171 | 99 | 12% |
| Industry | 2,575 | 1205 | 86 | 8% |
| Lodging | 1,515 | NA | 6 | NA |
| Medical | 3,222 | 2276 | 87 | 13% |
| Office | 1,974 | 1113 | 1123 | 3% |
| Other | 1,414 | 690 | 124 | 7% |
| Restaurant | 4,046 | 1444 | 65 | 7% |
| Retail | 2,830 | 1383 | 461 | 4% |
| School (K-12) | 2,239 | 779 | 1276 | 2% |
| Warehouse | 3,587 | 1980 | 1198 | 3% |
| **Weighted Total** | **2,744** | **991.00** | **4,580** | **1%** |

These hours are distributed as shown in Figure 3-1. The figure shows the relative density of the distribution, much like a histogram except for relative rather than absolute proportions. Most of the facility HOU are distributed normally; Apartments and Industry show a bimodal distribution.

Figure 3-1. Relative Distribution of Observed HOU by Facility Type



## Facility Lighting Hours to Operating Hours

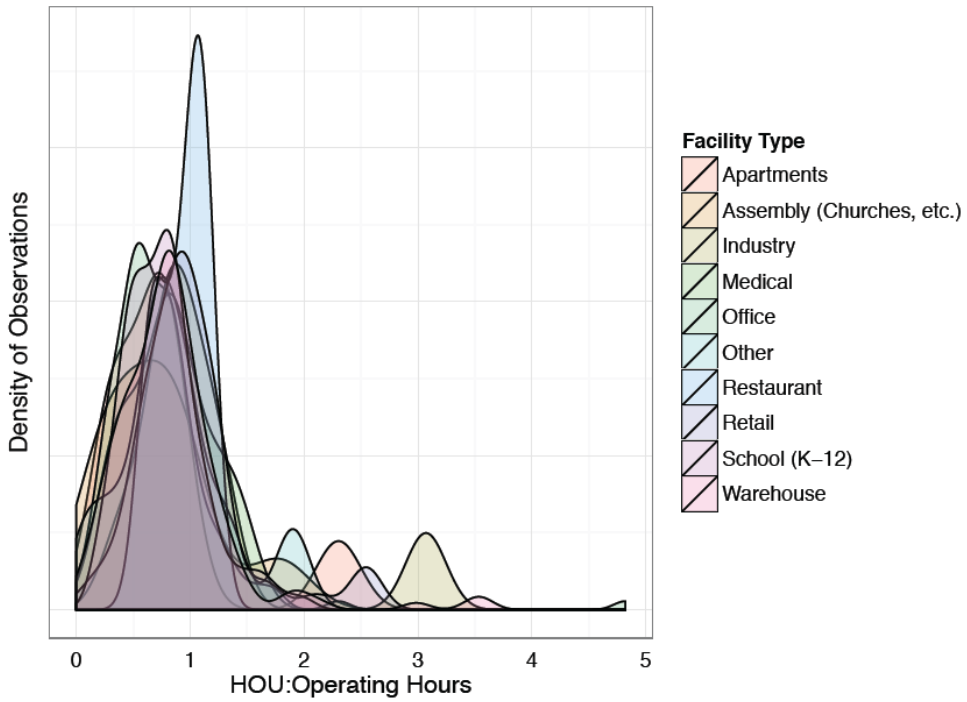
In addition, the research team asked site contacts to describe the operating hours of their facilities. These operating hours were then compared to the observed lighting hours to develop a lighting-to-operating-hour ratio, as shown in Table 3-2. The evaluation team completed this analysis to better understand how the operating characteristics of a facility impact the lighting hours-of-use.

Table 3-2. Lighting to Operating Hours Ratio by Facility Type with 90% Confidence

| Facility Type | Ratio of Lighting Hours-of-Use to Operating Hours | Std. Dev. | Loggers (n) | Relative Precision |
|---|---|---|---|---|
| Apartments | 0.84 | 0.19 | 55 | 5% |
| Assembly | 0.96 | 0.49 | 99 | 9% |
| Industry | 0.96 | 0.30 | 86 | 6% |
| Lodging | 1.43 | NA | 6 | NA |
| Medical | 0.55 | 0.45 | 87 | 14% |
| Office | 0.79 | 0.42 | 1123 | 3% |
| Other | 0.85 | 0.29 | 124 | 5% |
| Restaurant | 0.85 | 0.51 | 65 | 12% |
| Retail | 1.19 | 1.26 | 461 | 8% |
| School | 0.72 | 0.36 | 1276 | 2% |
| Warehouse | 0.78 | 0.47 | 1198 | 3% |
| **Weighted Total** | **0.95** | **0.23** | **4,580** | **1%** |

The distribution of these ratios is shown in Figure 3-2. The figure shows the density of the distribution, much like a histogram except for relative rather than absolute proportions. Most of the observations show lighting operating less than the facility operating hours. However, there are a few outliers, notably "other" facilities, apartments, retail locations, and industrial facilities.

Figure 3-2. Distribution of Lighting to Operating Hours Ratio by Facility Type



## Preliminary Facility Coincidence Factors

The coincidence factors estimated in this report are defined as the percentage of time that a light is on during the peak period of weekdays between 3PM to 6PM. These factors are intended to be used to calculate peak demand savings. Note that this first wave of data does not include the actual summer peak period, but presents the preliminary modeled coincidence factors using the data collected to date. These values will be updated when complete Wave 2 data are available that includes the summer peak. The weighted mean CF for these C&I facilities based only on the lighting study (Wave 1) is 0.51, while it is 0.35 based only on the lighting controls study.[12] Combined, these studies provide an estimate of 0.51, with 4,580 loggers covering 4,491 observed spaces.

Preliminary coincidence factors are presented by facility type in Table 3-3.

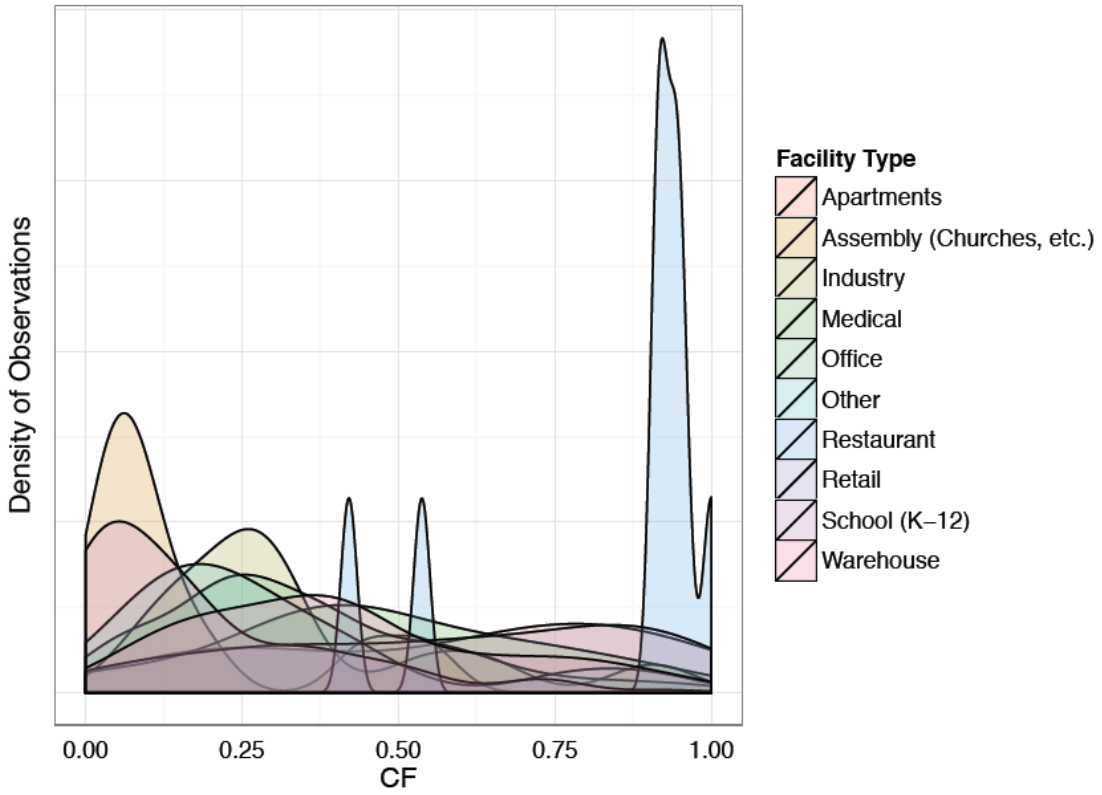
Table 3-3. Preliminary Coincidence Factors by Facility Type

| Facility Type | CF | Std. Dev. | Loggers (n) | Relative Precision |
|---|---|---|---|---|
| Apartments | 0.71 | 0.27 | 55 | 8% |
| Assembly (Churches, etc.) | 0.28 | 0.22 | 99 | 13% |
| Industry | 0.45 | 0.29 | 86 | 11% |
| Lodging | 0.17 | NA | 6 | NA |
| Medical | 0.59 | 0.26 | 87 | 8% |
| Office | 0.35 | 0.20 | 1123 | 3% |
| Other | 0.27 | 0.18 | 124 | 10% |
| Restaurant | 0.78 | 0.25 | 65 | 6% |
| Retail | 0.61 | 0.29 | 461 | 4% |
| School (K-12) | 0.19 | 0.17 | 1276 | 4% |
| Warehouse | 0.52 | 0.30 | 1198 | 3% |
| Weighted Total | 0.51 | 0.18 | 4,580 | 1% |

[12] Wave 1 includes all types of facilities; the data from the lighting controls study only include schools, offices, and warehouses.

These CF values are distributed as shown in Figure 3-3 and are much more widely distributed than the estimates for HOU. The Wave 2 metering data will likely improve the precision of these estimates.

Figure 3-3. Distribution of Observed CF by Facility Type



## Space Hours of Use

The research team summarized hours-of-use (HOU) by space type within facility types, as shown in Table 3-4. Some spaces are particularly low-use spaces, such as classroom spaces in "Other" facilities and gym spaces in Assembly facilities. For clarity, individual estimates are highlighted to indicate their value in relation to other values within the same facility type. That is, high HOU estimates within a facility are shaded green while low estimates are shaded red.

Table 3-4 Hours-of-Use by Space Type by Facility Type

| | Facility Type | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Space Type** | **Apartments** | **Assembly** | **Industry** | **Lodging** | **Medical** | **Office** | **Other** | **Restaurant** | **Retail** | **School (K-12)** | **Warehouse** |
| Assembly | 4,890 | 1,064 | NA | NA | NA | NA | 899 | NA | NA | NA | NA |
| Break Room | NA | 884 | 1,257 | NA | 1,200 | 1,829 | 1,682 | NA | 1,802 | 1,303 | 2,918 |
| Cafeteria | NA | 375 | NA | NA | NA | NA | NA | NA | NA | 2,356 | 1,775 |
| Classroom | NA | 596 | NA | NA | NA | NA | 172 | NA | 4,842 | 1,429 | NA |
| Conference | 4,035 | 488 | 1,671 | NA | 675 | 971 | 261 | NA | 1,018 | 1,221 | 1,277 |
| Dining | 1,448 | NA | NA | NA | NA | NA | 1,758 | 4,452 | NA | NA | NA |
| Equipment | NA | 707 | 780 | NA | 975 | 2,064 | 1,610 | 1,324 | 2,034 | NA | NA |
| Gym | 563 | 101 | NA | NA | NA | NA | 1,406 | NA | 6,566 | 2,545 | NA |
| Hallway | 8,528 | 1,424 | 2,995 | NA | 3,778 | 1,914 | 2,098 | 4,896 | 2,262 | 3,598 | 2,483 |
| Kitchen | 2,329 | 1,308 | 1,936 | NA | 3,818 | 2,037 | 308 | 5,081 | 1,737 | 1,626 | 1,925 |
| Library/CPU | NA | 1,782 | NA | NA | NA | NA | NA | NA | NA | 1,767 | NA |
| Office (Closed) | 1,929 | 678 | 1,620 | NA | 1,291 | 1,671 | 1,575 | 4,683 | 2,449 | 1,444 | 1,994 |
| Office (Open) | 3,020 | 2,734 | 2,334 | 8,760 | 2,455 | 2,378 | 2,223 | NA | 3,417 | 2,338 | 2,758 |
| Other | 4,366 | 2,213 | 1,215 | NA | 2,523 | 2,550 | 1,853 | NA | 3,263 | 2,111 | 2,202 |
| Production | NA | NA | 2,959 | NA | NA | 1,972 | NA | NA | 2,897 | NA | 3,351 |
| Restroom | 38 | 873 | 431 | 267 | 685 | 1,212 | 1,679 | 3,212 | 587 | 1,515 | 1,140 |
| Retail | NA | 3,184 | 2,632 | NA | 2,716 | 3,558 | NA | NA | 2,825 | NA | NA |
| Storage | 1,904 | 401 | 927 | 17 | 984 | 992 | 1,325 | 3,077 | 1,801 | 1,420 | 1,516 |
| Warehouse | NA | NA | 2,195 | NA | NA | 1,661 | 1,945 | NA | 2,550 | NA | 2,295 |

## Preliminary Space Coincidence Factors

The research team summarized CFs by space type within facility types, as shown in Table 3-5. The CFs estimated in this report are defined as the percentage of time that a light is on during the peak period of weekdays between 3PM to 6PM and intended to be used to calculate peak demand savings. Note that this first wave of data does not include the actual summer peak period, but presents the preliminary modeled coincidence factors using the data collected to date. These values will be updated when complete Wave 2 data are available that includes the summer peak. For clarity, individual estimates are highlighted to indicate their value in relation to other values within the same facility type. That is, high estimates within a facility are shaded green while low estimates are shaded red.

Table 3-5 Preliminary Coincidence Factors, by Space Type

| Space Type | Facility Type | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apartments | Assembly | Industry | Lodging | Medical | Office | Other | Restaurant | Retail | School (K-12) | Warehouse |
| Assembly | 0.62 | 0.14 | NA | NA | NA | NA | 0.18 | NA | NA | NA | NA |
| Break Room | NA | 0.21 | 0.20 | NA | 0.24 | 0.38 | 0.25 | NA | 0.39 | 0.06 | 0.49 |
| Cafeteria | NA | 0.07 | NA | NA | NA | NA | NA | NA | NA | 0.22 | 0.21 |
| Classroom | NA | 0.05 | NA | NA | NA | NA | 0.12 | NA | 0.81 | 0.12 | NA |
| Conference | 0.66 | 0.06 | 0.32 | NA | 0.06 | 0.19 | 0.04 | NA | 0.25 | 0.12 | 0.25 |
| Dining | 0.17 | NA | NA | NA | NA | NA | 0.33 | 0.88 | NA | NA | NA |
| Equipment | NA | 0.06 | 0.09 | NA | 0.26 | 0.36 | 0.33 | 0.09 | 0.37 | NA | NA |
| Gym | 0.18 | 0.00 | NA | NA | NA | NA | 0.88 | NA | 0.89 | 0.21 | NA |
| Hallway | 0.98 | 0.27 | 0.58 | NA | 0.75 | 0.33 | 0.44 | 0.93 | 0.51 | 0.35 | 0.41 |
| Kitchen | 0.37 | 0.21 | 0.44 | NA | 0.86 | 0.32 | 0.03 | 0.99 | 0.42 | 0.12 | 0.35 |
| Library/CPU | NA | 0.20 | NA | NA | NA | NA | NA | NA | NA | 0.12 | NA |
| Office (Closed) | 0.48 | 0.11 | 0.25 | NA | 0.31 | 0.29 | 0.27 | 0.92 | 0.51 | 0.13 | 0.35 |
| Office (Open) | 0.68 | 0.54 | 0.37 | 1.00 | 0.54 | 0.44 | 0.45 | NA | 0.60 | 0.20 | 0.46 |
| Other | 0.56 | 0.44 | 0.31 | NA | 0.48 | 0.44 | 0.16 | NA | 0.67 | 0.28 | 0.41 |
| Production | NA | NA | 0.42 | NA | NA | 0.42 | NA | NA | 0.70 | NA | 0.48 |
| Restroom | 0.01 | 0.16 | 0.06 | 0.03 | 0.15 | 0.21 | 0.29 | 0.60 | 0.11 | 0.12 | 0.21 |
| Retail | NA | 0.35 | 0.36 | NA | 0.42 | 0.70 | NA | NA | 0.66 | NA | NA |
| Storage | 0.49 | 0.06 | 0.10 | 0.00 | 0.15 | 0.13 | 0.26 | 0.51 | 0.40 | 0.12 | 0.24 |
| Warehouse | NA | NA | 0.27 | NA | NA | 0.30 | 0.23 | NA | 0.52 | NA | 0.38 |

## Lighting Equipment Inventory

The research team inventoried the lighting equipment in each space, sorting these by lighting type, wattage, and controls. The inventories included metered and non-metered lighting – all lighting in the facilities. We found that the majority of inventoried lighting across space types was fluorescent or incandescent, as shown in Table 3-6.

Table 3-6. Lighting Equipment Distribution for Each Space Type in Wave 1

| Space Type | CFL | Fluorescent | HID | Incandescent | Induction | LED | Other | Total |
|---|---|---|---|---|---|---|---|---|
| Assembly | 19.7% | 39.3% | -- | 40.5% | -- | 0.4% | -- | 100% |
| Break Room | 1.6% | 93.6% | -- | 4.8% | -- | -- | -- | 100% |
| Cafeteria | 8.5% | 83.7% | 6.8% | 1.1% | -- | -- | -- | 100% |
| Classroom | 0.4% | 99.6% | -- | 0.1% | -- | -- | -- | 100% |
| Conference | 1.4% | 84.9% | -- | 13.7% | -- | -- | -- | 100% |
| Dining | 4.2% | 50.9% | -- | 33.1% | -- | 6.1% | 5.6% | 100% |
| Equipment | 1.0% | 73.4% | 8.5% | 17.2% | -- | 0.0% | 0.0% | 100% |
| Gym | 0.2% | 20.6% | 79.2% | -- | -- | -- | -- | 100% |
| Hallway | 9.2% | 84.3% | 0.5% | 4.9% | 0.0% | 0.4% | 0.6% | 100% |
| Kitchen | 1.9% | 96.6% | 1.2% | -- | -- | 0.3% | -- | 100% |
| Library/CPU | 6.3% | 92.8% | -- | 0.9% | -- | -- | -- | 100% |
| Office (Closed) | 2.0% | 95.2% | -- | 2.8% | -- | -- | -- | 100% |
| Office (Open) | 3.0% | 92.8% | 0.8% | 3.3% | -- | 0.0% | -- | 100% |
| Other | 2.5% | 52.6% | 31.4% | 2.9% | -- | 9.8% | 0.8% | 100% |
| Production | -- | 66.9% | 33.1% | -- | -- | -- | -- | 100% |
| Restroom | 8.2% | 72.0% | -- | 19.6% | -- | 0.1% | -- | 100% |
| Retail | 2.3% | 75.7% | -- | 10.0% | -- | 0.3% | 11.6% | 100% |
| Storage | 1.8% | 73.7% | 17.4% | 7.0% | -- | 0.1% | -- | 100% |
| Warehouse | 0.5% | 72.2% | 26.9% | 0.1% | -- | -- | 0.4% | 100% |

Most of the lighting inventoried by the research team did not have lighting controls. Warehouse spaces and restrooms were most likely to have occupancy controls, as shown in Table 3-7. Note that existing controls were identified in the field, and thus the estimated values for HOU and CF include the effect of lighting controls.

Table 3-7. Portion of Lighting Wattage with Lighting Controls by Space Type in Wave 1

| Space Type | No Control | Occupancy Sensor |
|---|---|---|
| Assembly | 97.9% | 2.1% |
| Break Room | 97.0% | 3.0% |
| Cafeteria | 98.2% | 1.8% |
| Classroom | 98.9% | 1.1% |
| Conference | 99.7% | 0.3% |
| Dining | 100.0% | -- |
| Equipment | 99.3% | 0.7% |
| Gym | 100.0% | -- |
| Hallway | 98.6% | 1.4% |
| Kitchen | 95.1% | 4.8% |
| Library/CPU | 100.0% | -- |
| Office (Closed) | 98.3% | 1.7% |
| Office (Open) | 97.7% | 2.3% |
| Other | 99.9% | 0.1% |
| Production | 98.8% | 1.1% |
| Restroom | 88.9% | 11.1% |
| Retail | 100.0% | -- |
| Storage | 98.7% | 1.3% |
| Warehouse | 64.9% | 35.1% |

## 3.2 Descriptive Statistics

This section provides descriptive statistics for participant facility types, incidence study facility types, the number of loggers per facility type, the space types metered, and facility square footage for Wave 1. These data are provided in order to assess the representativeness of the study sample.

### Participant Facility Types

The research team recruited participants for on-site metering from randomly selected Consumers Energy and DTE Energy customer samples.[13] Table 3-8 shows the facility types of the first wave of metering study participants. The retail facilities included gas stations, automotive service centers, clothing sales, comic book store, and convenience stores. The medical facilities include a family medicine center, dental offices, and a urology clinic. There were two fast food and eight full service restaurants.

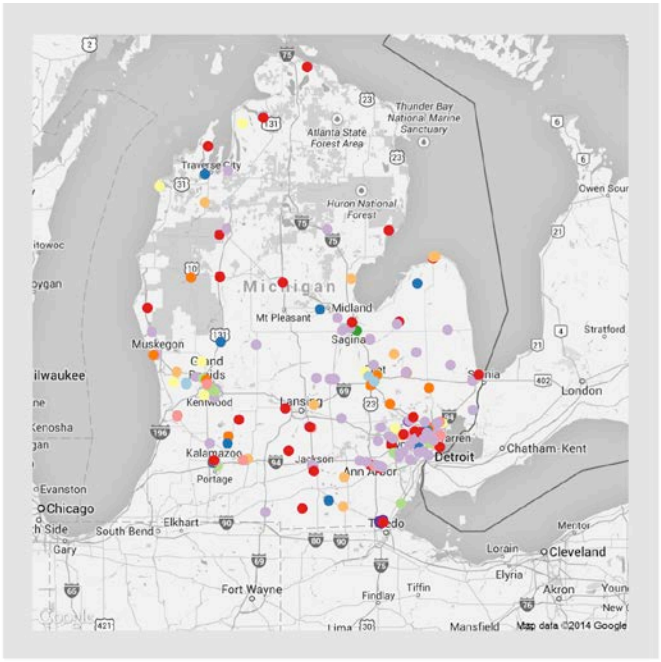
Table 3-8. Facility Types Included in Metering Study, Wave 1

| Facility Type | Count | Percent |
|---|---|---|
| Apartments | 9 | 5% |
| Assembly (Churches, etc.) | 10 | 6% |
| Industry | 12 | 7% |
| Lodging | 1 | 1% |
| Medical | 9 | 5% |
| Office | 31 | 17% |
| Other | 17 | 9% |
| Restaurant | 9 | 5% |
| Retail | 68 | 38% |
| School (K-12) | 6 | 3% |
| Warehouse | 8 | 4% |
| Total | 180 | 100% |

[13] Our sample included general C&I rate customers only; as such the data may not be applicable to the largest industrial customers. However, in general these customers most often complete self-directed or custom projects.

As discussed above, the sample for this study was selected from Consumers Energy and DTE Energy customer records. As part of our recruiting effort, we recruited facilities located throughout the Lower Peninsula, as shown in Figure 3-4 below.

Figure 3-4 Locations of Facilities in the Metering Study, Wave 1



## Incidence Study Facility Types

The study included a facility incidence study; the distributions from this study are shown in Table 3-9. This was a random sample of the population, and the results are expected to be representative of the distribution of facility types in Michigan. The portion of facilities is used to weight the overall averages for HOU and CF.

Table 3-9. Facility Types as Reported by All Facilities through Incidence Study

| Facility Type | Count | Percent |
|---|---|---|
| Apartments | 53 | 6% |
| Assembly (Churches, etc.) | 61 | 7% |
| Industry | 65 | 7% |
| Lodging | 9 | 1% |
| Medical | 47 | 5% |
| Office | 211 | 24% |
| Other/None of the above | 59 | 7% |
| Restaurant | 47 | 5% |
| Retail | 288 | 33% |
| School (College/University) | 1 | <1% |
| School (K-12) | 20 | 2% |
| Warehouse | 25 | 3% |
| Total | 886 | 100% |
| Refused to Provide | 115 | -- |

## Loggers by Facility Type

Lighting loggers were installed at 180 facilities for the first metering period of this study. Altogether the research team installed 1,360 loggers with an average of 7.6 loggers per facility, as shown in Table 3-10.

Table 3-10. Loggers by Facility Type in Wave 1

| Facility Type | Loggers | Percent |
|---|---|---|
| Apartments | 55 | 4% |
| Assembly (Churches, etc.) | 99 | 7% |
| Industry | 86 | 6% |
| Lodging | 6 | 0% |
| Medical | 87 | 6% |
| Office | 266 | 20% |
| Other | 127 | 9% |
| Restaurant | 65 | 5% |
| Retail | 461 | 34% |
| School (K-12) | 60 | 4% |
| Warehouse | 48 | 4% |
| Total | 1,360 | 100% |

The lighting controls study includes an additional 3,224 loggers installed at 377 facilities, with an average of 8.6 loggers per facility as shown in Table 3-11.

Table 3-11. Loggers by Facility Type in Lighting Controls Data

| Facility Type | Loggers | Percent |
|---|---|---|
| Office | 857 | 27% |
| School (K-12) | 1,216 | 38% |
| Warehouse | 1,151 | 36% |
| Total | 3,224 | 100% |

## Space Types

Table 3-12 shows the space types that were observed in the Wave 1 study. The most commonly observed spaces across facilities types were closed offices, restrooms, and storage. The space types that accounted for the most lighting wattage are classrooms and other.

Table 3-12. Metered Space Types across All Facilities in Wave 1

| Space Type | Number of Spaces | Percent of Spaces | Lighting Wattage | Percent of Lighting Wattage | Loggers | Percent of Loggers |
|---|---|---|---|---|---|---|
| Assembly | 80 | 2.46% | 55,807 | 2.95% | 34 | 2.5% |
| Break Room | 63 | 1.94% | 21,073 | 1.11% | 45 | 3.3% |
| Cafeteria | 20 | 0.62% | 29,668 | 1.57% | 7 | 0.5% |
| Classroom | 297 | 9.15% | 344,169 | 18.17% | 47 | 3.5% |
| Conference | 95 | 2.93% | 47,895 | 2.53% | 43 | 3.2% |
| Dining | 40 | 1.23% | 13,652 | 0.72% | 22 | 1.6% |
| Equipment | 125 | 3.85% | 56,620 | 2.99% | 58 | 4.3% |
| Gym | 21 | 0.65% | 90,675 | 4.79% | 10 | 0.7% |
| Hallway | 342 | 10.54% | 155,764 | 8.22% | 112 | 8.2% |
| Kitchen | 68 | 2.09% | 24,276 | 1.28% | 45 | 3.3% |
| Library/CPU | 19 | 0.59% | 26,877 | 1.42% | 6 | 0.4% |
| Office (Closed) | 488 | 15.03% | 133,836 | 7.07% | 210 | 15.4% |
| Office (Open) | 208 | 6.41% | 152,775 | 8.07% | 128 | 9.4% |
| Other | 288 | 8.87% | 255,062 | 13.47% | 125 | 9.2% |
| Production | 58 | 1.79% | 82,252 | 4.34% | 35 | 2.6% |
| Restroom | 435 | 13.40% | 54,208 | 2.86% | 175 | 12.9% |
| Retail | 128 | 3.94% | 72,166 | 3.81% | 63 | 4.6% |
| Storage | 385 | 11.86% | 131,200 | 6.93% | 142 | 10.4% |
| Warehouse | 86 | 2.65% | 145,830 | 7.70% | 53 | 3.9% |
| Total | 3,246 | 100.0% | 1,893,805 | 100% | 1,360 | 100% |

## Square Footage

The research team also collected information on facility square footage during the installation of loggers. Table 3-13 shows the square footage by facility type for the 134 sites where this information was available. For the remaining sites facility contacts were not able to provide the size of the facility.

Square footage is not used in this study; however, it is useful for consideration of how the sample relates to the population. Compared to the average square footage for all commercial buildings of those types, the office and retail facilities in the study are small; the Buildings Energy Data Book estimates an average of 14,800 square feet on average for offices and 9,700 square feet for retail facilities (non-mall).[14] Also, the warehouse facilities in the study are larger than the national average of 16,900 square feet. These differences could indicate a difference between facilities in Michigan and the national average, or they could indicate sample bias towards smaller offices and retail facilities and larger warehouse spaces. In our experience, larger office and retail facilities are more difficult to recruit for studies, as the key site contacts are difficult to reach. Larger offices and retail spaces may be open longer hours, thus indicating the potential for estimates in this study to be conservative.

Table 3-13. Square Footage by Facility Type in Wave 1

| Facility Type | Count | Mean | S.D. |
|---|---|---|---|
| Apartments | 9 | 3,644 | 3,880 |
| Assembly (e.g., churches) | 7 | 36,000 | 67,863 |
| Industry | 9 | 14,759 | 18,528 |
| Medical | 7 | 3,986 | 3,040 |
| Office | 24 | 4,337 | 5,700 |
| Other | 11 | 8,059 | 12,816 |
| Restaurant | 6 | 3,029 | 943 |
| Retail | 52 | 5,857 | 8,088 |
| School (K-12) | 1 | 38,000 | NA |
| Warehouse | 8 | 29,288 | 63,371 |
| Total | 134 | 14,696 | 23,845 |

As mentioned earlier, the square footage of the average office space in our sample is below the national average. To confirm that our sample was representative we compared our sample against several data sources. These included data from DTE Energy's customer database, Consumers Energy's customer database, and the ENERGY STAR Building Performance Database. All three of these sources confirmed that Michigan offices are smaller than the national average and provided estimates of office square footage in-line with our sample. In addition, analysis of HOU and square footage data from our research indicates no significant

[14] Department of Energy. 2011. Buildings Energy Data Book. Table 3.2.8. Retrieved from: http://buildingsdatabook.eren.doe.gov/DataBooks.aspx

relationship, suggesting that even if our sample is not representative of larger offices, this would not bias our HOU estimates.[15]

[15] This is discussed in Appendix B.

## 3.3 Heating and Cooling Equipment

Finally, the research team collected data on heating and cooling system types for the inventoried spaces during the on-site visits for Wave 1 (3,249 spaces). The distribution of heating systems is summarized in Table 3-14. The study indicates that more than half of the inventoried sites use some type of gas furnace heating system.

Table 3-14. Heating Type Inventory by Space in Wave 1

| Heating Type | Number of Spaces | Percent |
|---|---|---|
| Boiler (Hot Water) | 631 | 19.4% |
| Boiler (Steam) | 170 | 5.2% |
| Electric Resistance | 24 | 0.7% |
| Gas Furnace | 1,584 | 48.8% |
| Gas Furnace (Condensing) | 171 | 5.3% |
| Heat Pump (Air) | 3 | 0.1% |
| Heat Pump (Geothermal) | 174 | 5.4% |
| None | 70 | 2.2% |
| Other | 112 | 3.4% |
| Radiant | 11 | 0.3% |
| Unknown | 299 | 9.2% |
| **Total** | **3,249** | **100.0%** |

The research team also recorded heating equipment efficiency during the on-sites. Table 3-15 presents the recorded system efficiency values by system type across 2,768 spaces where the information was available.

Table 3-15. Recorded Heating Equipment Efficiency (n=2,768)

| Heating Type | Value | Units | Count |
|---|---|---|---|
| Boiler Hot Water | 0.80 | - | 631 |
| Boiler Steam | 0.75 | - | 170 |
| Electric Resistance | 1.00 | - | 24 |
| Gas Furnace | 0.80 | - | 1,584 |
| Gas Furnace Condensing | 0.93 | - | 171 |
| Heat Pump Air | 3.10 | COP | 3 |
| Heat Pump Geothermal | 3.60 | COP | 174 |
| Radiant | 0.80 | - | 11 |

Similarly, the research team collected data on cooling system types during the on-sites. The distribution of cooling systems is summarized in **Table 3-16**. Just over half of the inventoried sites use direct expansion (DX) cooling.

**Table 3-16. Cooling Type Inventory by Space**

| Cooling Type | Number of Spaces | Percent |
|---|---|---|
| Chiller Air Cooled | 47 | 1.4% |
| Chiller Centrifugal | 123 | 3.8% |
| Chiller Scroll | 38 | 1.2% |
| Direct Expansion | 1,710 | 52.6% |
| Heat Pump Air | 3 | 0.1% |
| Heat Pump Geo | 175 | 5.4% |
| None | 771 | 23.7% |
| Other | 71 | 2.2% |
| Unknown | 311 | 9.6% |
| Total | 3,249 | 100.0% |

Finally, the research team recorded the cooling equipment efficiency during the on-sites. Table 3-17 presents the recorded system efficiency by system type across 784 spaces where the information was available.

Table 3-17. Recorded Cooling Equipment Efficiency (n=784)

| Cooling Type | Value | Units | Count |
|---|---|---|---|
| Chiller Air Cooled | 4.50 | COP | 25 |
| Chiller Centrifugal | 4.90 | COP | 123 |
| Chiller Scroll | 4.50 | COP | 38 |
| Direct Expansion* | 9.29 | EER | 246 |
| Direct Expansion* | 11.90 | SEER | 309 |
| Heat Pump Air | 9.10 | EER | 3 |
| Heat Pump Geothermal | - | - | - |

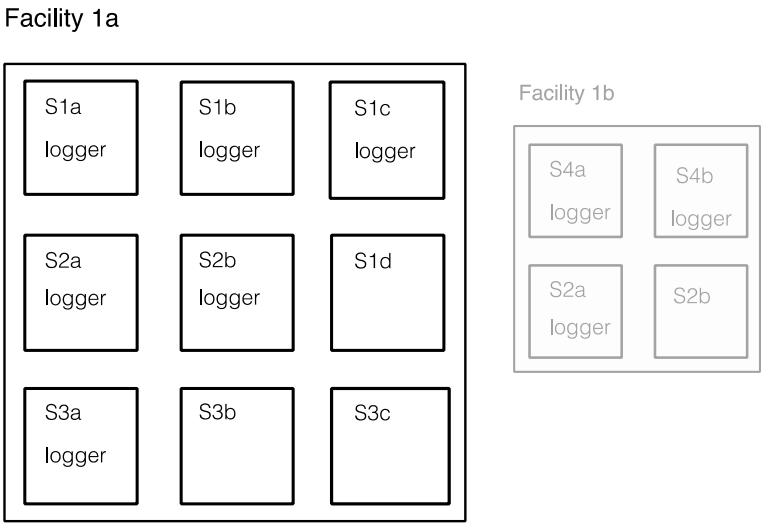
*For Direct Expansion, efficiencies were recorded as either EER or SEER. They are reported according to recorded units.

# APPENDIX A: FACILITY-TYPE WEIGHTING

**Objective**:
Determine Facility Type mean (μ) for HOU and CF, using data from metered subset of spaces within facilities

**Given**:

- Facility Type, F
  - F1a, F1b are two facilities of the same facility type F1 (see diagram)
- Space Type, S
  - S1, S2, S3, S4 are spaces of different types; S1a and S1b are different spaces of the same type (see diagram)
  - A space of a given space type may or may not be metered ("logger" in diagram)




**Summary of approach:**
To extrapolate to the population of C&I facilities for a given facility type, the evaluation team weighted logger data values to account for how much of a sampled facility's space type is represented by the logger data (steps 1,2 below), how much of each sampled facility is represented by each space type (step 3), and how much each total facility type is represented by each sampled facility (step 4).

1. For each Facility Space Type in a given facility (F1a), we calculated metered space type watts and total space type watts
   a. $Metered(S1watts) = S1a,watts + S1b,watts + S1c,watts$
   b. $Total(S1watts) = S1a,watts + S1b,watts + S1c,watts + S1d,watts$
2. For each Facility Space Type in a given facility (F1a), we calculated the mean (μ) of the observed values (v) of HOU or CF where loggers were installed
   a. $S1\mu = \frac{S1a,wattsMetered(S1watts)}{} \times S1a,v + \frac{S1b,watts}{Metered(S1watts)} \times S1b,v + \frac{S1c,watts}{Metered(S1watts)} \times S1c,v$
   b. $S2\mu = \frac{S2a,watts}{Metered(S2watts)} \times S2a,v + \frac{S2b,watts}{Metered(S2watts)} \times S2b,v$

c. $S3\mu = \frac{S3a,watts}{Metered(S3watts)} \times S3a,v$

3. For each Facility (F1a), **we** calculated total facility watts and facility mean (μ) of value (v) of HOU or CF
   a. $Total(F1a,watts) =$ $Total(\text{F1a, S1watts}) + Total(\text{F1a, S2watts}) + Total(\text{F1a, S3watts})$
   b. $F1a,\mu = \frac{Total(S1watts)}{Total(F1a,watts)} \times S1\mu + \frac{Total(S2watts)}{Total(F1a,watts)} \times S2\mu + \frac{Total(S3watts)}{Total(F1a,watts)} \times S3\mu$
4. For each Facility Type (F1), we calculated total facility type watts and mean (μ) of value (v) of HOU or CF
   a. $Total(F1watts) = F1a,watts + F1b,watts$
   b. $F1,\mu = \frac{F1a,watts}{Total(F1,watts)} \times F1a,\mu + \frac{F1b,watts}{Total(F1b,watts)} \times F1b,\mu$

# APPENDIX B: SUPPORTING INFORMATION

There was no significant difference between weighting by lighting wattage, as was carried out in this study, and weighting by number of bulbs. Tables for both types of weighting at the space type by facility type for Wave 1 are shown here for reference.

Table 3-18. HOU Weighted on Lighting Wattage, Wave 1, by Space Type by Facility Type

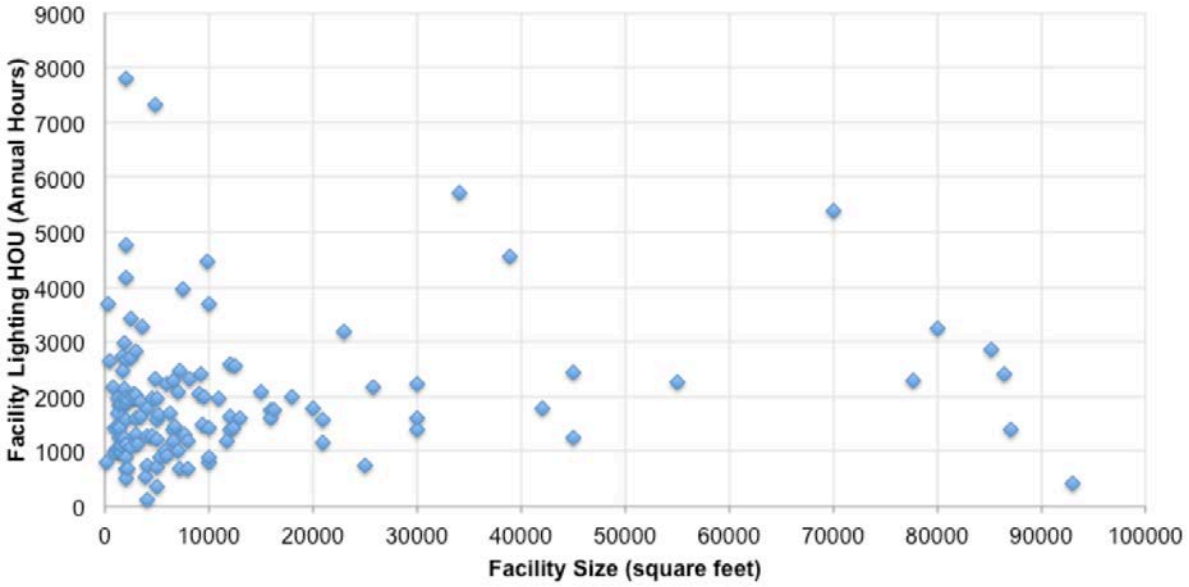
| Space | Apartments | Assembly | Industry | Lodging | Medical | Office | Other | Restaurant | Retail | School | Warehouse |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Assembly | 4,890 | 1,064 | NA | NA | NA | NA | 899 | NA | NA | NA | NA |
| Breakroom | NA | 884 | 1,257 | NA | 1,200 | 1,498 | 1,682 | NA | 1,802 | NA | 1,031 |
| Cafeteria | NA | 375 | NA | NA | NA | NA | NA | NA | NA | 3,126 | 1,775 |
| Classroom | NA | 596 | NA | NA | NA | NA | 172 | NA | 4,842 | 1,838 | NA |
| Conference | 4,035 | 488 | 1,671 | NA | 675 | 800 | 261 | NA | 1,018 | 1,814 | NA |
| Dining | 1,448 | NA | NA | NA | NA | NA | 1,758 | 4,452 | NA | NA | NA |
| Equipment | NA | 707 | 780 | NA | 975 | 2,064 | 1,610 | 1,324 | 2,034 | NA | NA |
| Gym | 563 | 101 | NA | NA | NA | NA | 1,406 | NA | 6,566 | 3,943 | NA |
| Hallway | 8,528 | 1,424 | 2,995 | NA | 3,778 | 1,542 | 2,098 | 4,896 | 2,262 | 4,144 | 2,760 |
| Kitchen | 2,329 | 1,308 | 1,936 | NA | 3,818 | 2,474 | 308 | 5,081 | 1,737 | NA | 2,783 |
| Library/ CPU | NA | 1,782 | NA | NA | NA | NA | NA | NA | NA | 2,556 | NA |
| Office-Closed | 1,929 | 678 | 1,620 | NA | 1,291 | 1,921 | 1,575 | 4,683 | 2,449 | 1,581 | 1,583 |
| Office-Open | 3,020 | 2,734 | 2,334 | 8,760 | 2,455 | 2,284 | 2,223 | NA | 3,417 | 2,470 | 1,862 |
| Other | 4,366 | 2,213 | 1,215 | NA | 2,523 | 3,035 | 1,853 | NA | 3,263 | 1,406 | 6,814 |
| Production | NA | NA | 2,959 | NA | NA | NA | NA | NA | 2,897 | NA | 4,519 |
| Restroom | 38 | 873 | 431 | 267 | 685 | 977 | 1,679 | 3,212 | 587 | 3,834 | 1,809 |
| Retail | NA | 3,184 | 2,632 | NA | 2,716 | 3,558 | NA | NA | 2,825 | NA | NA |
| Storage | 1,904 | 401 | 927 | 17 | 984 | 1,155 | 1,325 | 3,077 | 1,801 | NA | 1,103 |
| Warehouse | NA | NA | 2,195 | NA | NA | 1,901 | 1,945 | NA | 2,550 | NA | 2,543 |

Table 3-19 HOU Weighted on Number of Bulbs, Wave 1, by Space Type by Facility Type

| Space | Apartments | Assembly | Industry | Lodging | Medical | Office | Other | Restaurant | Retail | School | Warehouse |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Assembly | 4,904 | 1,073 | NA | NA | NA | NA | 1,056 | NA | NA | NA | NA |
| Breakroom | NA | 884 | 1,257 | NA | 1,200 | 1,498 | 1,682 | NA | 1,802 | NA | 1,031 |
| Cafeteria | NA | 375 | NA | NA | NA | NA | NA | NA | NA | 2,864 | 1,775 |
| Classroom | NA | 547 | NA | NA | NA | NA | 172 | NA | 4,744 | 1,747 | NA |
| Conference | 3,988 | 488 | 1,671 | NA | 675 | 805 | 307 | NA | 938 | 1,814 | NA |
| Dining | 1,448 | NA | NA | NA | NA | NA | 3,175 | 4,443 | NA | NA | NA |
| Equipment | NA | 707 | 2,167 | NA | 975 | 2,064 | 1,946 | 1,324 | 1,985 | NA | NA |
| Gym | 563 | 101 | NA | NA | NA | NA | 1,406 | NA | 6,566 | 3,943 | NA |
| Hallway | 8,528 | 1,411 | 2,995 | NA | 3,777 | 1,568 | 2,093 | 4,751 | 2,274 | 4,144 | 2,760 |
| Kitchen | 2,329 | 1,308 | 1,936 | NA | 3,818 | 2,474 | 308 | 5,000 | 1,737 | NA | 2,783 |
| Library/ CPU | NA | 1,782 | NA | NA | NA | NA | NA | NA | NA | 2,556 | NA |
| Office-Closed | 1,793 | 675 | 1,584 | NA | 1,322 | 1,862 | 1,546 | 4,683 | 2,441 | 1,581 | 1,503 |
| Office-Open | 3,860 | 2,734 | 2,334 | 8,760 | 2,248 | 2,232 | 2,345 | NA | 3,416 | 2,470 | 1,845 |
| Other | 4,407 | 1,939 | 1,160 | NA | 2,452 | 2,810 | 1,845 | NA | 3,266 | 1,406 | 6,814 |
| Production | NA | NA | 2,983 | NA | NA | NA | NA | NA | 2,841 | NA | 4,519 |
| Restroom | 38 | 889 | 439 | 228 | 692 | 969 | 1,662 | 3,081 | 586 | 3,834 | 1,809 |
| Retail | NA | 3,184 | 2,632 | NA | 2,716 | 3,558 | NA | NA | 2,785 | NA | NA |
| Storage | 1,904 | 401 | 927 | 17 | 1,000 | 1,162 | 1,423 | 3,077 | 1,779 | NA | 988 |
| Warehouse | NA | NA | 2,195 | NA | NA | 1,785 | 1,872 | NA | 2,512 | NA | 2,408 |

There is no significant relationship between office size and HOU. Figure 3-5 shows a weakly positive relationship between HOU and office size based on our sample (it excludes two large outliers). The correlation is 0.14 with a P of 0.1164 (i.e., not significant). That is, larger offices don't necessarily have higher HOU for their lighting.

Figure 3-5 Office Facility Lighting HOU by Facility Size, Wave 1 and LCS Facilities Less than 100,000 Square Feet




There is some variation in lighting use by the facility operating schedule. The HOU from the loggers in this study are shown in Table 3-20 by facility type and reported operating hours, in four categories: Less than 1,000 hours of operation per year, more than 1,000 but less than 3,000 hours, more than 3,000 but less than 5,000 hours, and more than 5,000 hours of operation per year. These categories reflect very low use facilities, typical business day operations, longer day operations, and full time operations.

Table 3-20 HOU by Facility Type and Reported Hours

| Facility Type | Reported Hours | HOU | cv |
|---|---|---|---|
| Apartments | 1000 - 2999 | 3,580 | 0.84 |
| Apartments | More than 5000 | 6,112 | 0.23 |
| Assembly (Churches, etc.) | Less than 1000 | 538 | 0.18 |
| Assembly (Churches, etc.) | 1000 - 2999 | 1,141 | 0.72 |
| Assembly (Churches, etc.) | 3000 - 4999 | 2,788 | NA |
| Assembly (Churches, etc.) | NA | 499 | NA |
| Industry | Less than 1000 | 541 | 0.01 |
| Industry | 1000 - 2999 | 2,529 | 0.52 |
| Industry | More than 5000 | 3,391 | NA |
| Industry | NA | 2,735 | 0.35 |
| Lodging | More than 5000 | 1,515 | NA |
| Medical | 1000 - 2999 | 2,186 | 0.42 |
| Medical | 3000 - 4999 | 2,434 | NA |
| Medical | NA | 5,472 | 0.68 |
| Office | Less than 1000 | 502 | 0.69 |
| Office | 1000 - 2999 | 1,958 | 0.56 |
| Office | 3000 - 4999 | 1,686 | 0.44 |
| Office | More than 5000 | 2,272 | 0.70 |
| Office | NA | 2,167 | 0.33 |
| Other | 1000 - 2999 | 1,555 | 0.46 |
| Other | More than 5000 | 830 | NA |
| Other | NA | 918 | 0.47 |
| Restaurant | 3000 - 4999 | 3,650 | 0.43 |
| Restaurant | More than 5000 | 5,471 | 0.02 |
| Restaurant | NA | 4,381 | 0.01 |
| Retail | Less than 1000 | 2,239 | NA |
| Retail | 1000 - 2999 | 2,547 | 0.51 |
| Retail | 3000 - 4999 | 3,269 | 0.19 |
| Retail | More than 5000 | 5,588 | 0.28 |
| Retail | NA | 1,291 | 0.73 |
| School (K-12) | 1000 - 2999 | 2,054 | 0.32 |
| School (K-12) | 3000 - 4999 | 2,402 | 0.41 |
| School (K-12) | More than 5000 | 2,964 | 0.59 |
| School (K-12) | NA | 2,364 | 0.30 |
| Warehouse | 1000 - 2999 | 3,433 | 0.62 |
| Warehouse | 3000 - 4999 | 2,773 | 0.33 |
| Warehouse | More than 5000 | 5,174 | 0.37 |