

# 1 M&V Guidelines for Lighting Efficiency Measures

## 1.1 Overview

The lighting projects covered by this M&V procedure are lighting efficiency measures that may include the replacement of existing lamps and ballasts with new energy efficient lamps and ballasts.

For these types of projects, demand savings are based on coincident-load factors and changes in lighting load as determined using standard lighting fixture wattage values listed in the Entergy Lighting Table of Standard Fixture Wattages. To determine energy savings, the Sponsor should establish operating hours using one of two methods:

**Stipulated Hours Method** – Energy savings are based on whole building stipulated operating hours established for certain building types (See Table 1.1).

**Metered Hours Method** – Energy savings are determined by metering post-installation operating hours using defined sampling techniques.

For lighting efficiency measures installed in electrically cooled spaces, demand and energy savings are also given for lighting-HVAC system interaction. These savings are equal to **10%** of the lighting demand savings and **5%** of lighting energy savings, respectively.

In addition to determining operating hours, the Project Sponsor is required to conduct pre- and post-installation equipment surveys. The Project Sponsor should fill out and submit survey results in the standard Lighting Equipment Survey using fixture codes provided in the Standard Wattage Table. Entergy or its contractor will conduct pre- and post-installation inspections to verify the reported baseline and retrofit conditions, respectively.

## 1.2 Stipulated Hours Method

The procedures outlined below should be followed when the project qualifies for using the stipulated hours M&V approach for lighting efficiency projects. Qualifying projects are those accurately characterized by building type and lighting-system operation in Table 1.1. The Stipulated Hours Method may only be used for those building types listed in Table 1.1 without exception. Buildings of types not listed in Table 1.1 are required to use the Metered Hours Method of M&V (see Section 1.3).

### 1.2.1 Pre-installation M&V Activities

#### 1.2.1.1 Pre-installation equipment survey

Prior to installing the lighting retrofit, the Project Sponsor conducts a pre-installation equipment survey, to be submitted as part of the Final Application. The purpose of the pre-installation equipment survey is to inventory all existing lighting equipment, and to propose the replacement equipment to be installed. This survey should provide the following information about all fixtures: room location, fixture, lamp, and ballast types, lighting controls, area designations, counts of operating and non-operating fixtures, and type of control device. Surveys should include all baseline lighting fixtures and controls,

regardless of whether they will be retrofitted. Fixture wattages are based on the fixture codes listed in the Standard Wattage Table. This information should be tabulated electronically in the Lighting Equipment Survey.

### *Non-operating fixtures*

For non-operating fixtures, the baseline demand may be adjusted by using values from the Standard Wattage Table. **The number of non-operating fixtures will be limited to 10% of the total fixture count per facility.** If, for example, more than 10% of the total number of fixtures is inoperative, the number of fixtures beyond 10% will be assumed to have a baseline fixture wattage of zero. Thus, the total baseline demand for the project will be adjusted accordingly.

#### **1.2.1.2 Pre-installation inspection**

Entergy or its contractor will conduct a pre-installation inspection to verify that the Sponsor has properly documented the baseline. The criterion for baseline acceptance is that the error in the installed demand must be within  $\pm 5\%$  of the demand reported on the Lighting Equipment Survey. If the error exceeds  $\pm 5\%$ , the Sponsor is allowed to resubmit corrected lighting tables. If the project fails inspection twice due to incorrect survey forms, the Project Sponsor will bear the cost of subsequent inspections. Pre-installation operating hours

The operating hours of the baseline lighting system are assumed to be the same as those of the post-retrofit lighting system and are not measured as part of the pre-installation M&V activities.

### **1.2.2 Post-installation M&V Activities**

#### **1.2.2.1 Post-installation equipment survey**

The Sponsor is required to conduct a post-installation lighting equipment survey as part of the Installation Report. The purpose of the post-installation equipment survey is to inventory the actual, as-built post-retrofit equipment. Fixture wattages shall be based on the Standard Wattage Table. In the Installation Report, the proposed equipment information listed in the approved Final Application shall be updated to reflect the actual post-retrofit conditions and equipment found during the survey after installation. Any equipment listed in the approved Final Application that was not in fact replaced should remain in the lighting equipment inventory – in this case, simply copy the pre-retrofit information to the post-retrofit columns.

#### **1.2.2.2 Post-installation inspection**

Entergy or its contractor will conduct a post-installation inspection to verify that the retrofit was installed as reported. In most cases, Entergy or its contractor will inspect statistically significant samples taken from the entire lighting population. The criterion for acceptance is that the error in the installed demand of the sample must be within  $\pm 5\%$  of the demand reported on the post-installation lighting equipment inventory form. If the error exceeds  $\pm 5\%$ , Entergy will inform the Sponsor that the submitted lighting survey must be corrected and resubmitted, citing the major cause of the errors found.

#### **1.2.2.3 Operating hours**

The **Stipulated Hours Method** uses stipulated annual operating hours as listed in Table 1.1. If this table does not accurately characterize the building type, then the Project Sponsor should refer to the **Metered Hours Method** section for the appropriate M&V techniques for measuring operating hours for lighting efficiency measures.

**Table 1.1: Stipulated Operating Hours, Coincidence Factors, and Interactive Savings**

Building Type	Stipulated Annual Operating Hours	Avg. On-Peak Demand Coincidence Factor	Interactive HVAC Demand Savings	Interactive HVAC Energy Savings
Office	3,760	80%	10%	5%
Non 24-Hour Supermarket/Retail	4,250	95%	10%	5%
24-Hour Supermarket/Retail	6,900	95%	10%	5%
Education (K-12; no summer)	2,150	82%	10%	5%
In-Patient Health Care	3,750	60%	10%	5%

The first column in Table 1.1 presents the stipulated, whole-building, annual operating hours for the building types listed. The retrofit energy savings are determined from the operating hours and the kW reduction determined from the lighting tables. The average on-peak demand coincidence factor (CF) in the second column is the ratio of the average on-peak operating hours of all lighting circuits to the total number of Entergy on-peak hours during the monitoring period. The retrofit demand savings are determined from the CF in column two and the kW reduction determined from the Standard Wattage Table.

**1.2.3 Calculation of Demand and Energy Savings**

The peak demand savings and energy savings are calculated according to Equations 1.1 through 1.6. Demand savings are only allowed for lighting fixtures that will be in operation on weekdays between the hours of 1 PM and 7 PM during the months of May through September. Total demand savings are calculated by multiplying the kW savings by the CF for the appropriate building type, from Table 1.1. The CF is used to adjust total installed lighting demand for the actual percentage of fixtures operating during Entergy’s peak demand hours. The CF is also applied to the interactive savings since interactive savings are a direct result of lighting operation.

Interactive HVAC demand and energy savings may be calculated only for lighting retrofits taking place in air-conditioned spaces. Lighting retrofits in unconditioned spaces, such as parking garages, are not eligible for interactive HVAC savings payments. For eligible projects, the interactive HVAC demand savings is a fixed percentage set at **10%** of the lighting demand savings. Similarly, the interactive HVAC energy savings is fixed and equal to **5%** of the lighting energy savings.

**1.2.3.1 Peak Demand Savings**

**Equation 1.1:**

$$\text{Connected Lighting Load Reduction [kW]} = \text{Pre Lighting Demand [kW]} - \text{Post Lighting Demand [kW]}$$

**Equation 1.2:**

$$\text{Interactive HVAC Demand Savings [kW]} = \text{Connected Lighting Load Reduction [kW]} * 0.10$$

**Equation 1.3:**

$$\text{Total Demand Savings [kW]} = (\text{Connected Lighting Load Reduction [kW]} + \text{Interactive HVAC Demand Savings [kW]}) * \text{Coincidence Factor}$$

**1.2.3.2 Energy savings****Equation 1.4:**

$$\text{Lighting Energy Savings [kWh]} = \frac{\text{Connected Lighting Load Reduction [kW]} * \text{Annual Operating Hours [hrs]}}{\text{Annual Operating Hours [hrs]}}$$

**Equation 1.5:**

$$\text{Interactive HVAC Energy Savings [kWh]} = \text{Lighting Energy Savings [kWh]} * 0.05$$

**Equation 1.6:**

$$\text{Total Energy Savings [kWh]} = \text{Lighting Energy Savings [kWh]} + \text{Interactive HVAC Energy Savings [kWh]}$$

**1.2.4 Example**

The following is an example of how the M&V procedures described above would be applied using the Stipulated Hours Method to determine the operating hours and annual energy savings.

**Example<sup>1</sup>**

A lighting efficiency project is proposed for a typical small office building. The Project Sponsor submits the Lighting Inventory survey forms as part of the Final Application detailing the existing and proposed equipment. The table below summarizes the existing and proposed connected lighting load for each usage group in the project. The CF for office buildings is **80%**.

Area Description	Survey Lines	Connected Lighting Load (kW)			Stipulated Operating Hours	Annual kWh Savings	Actual kW Savings
		Existing	Proposed	Difference			
Hallways and Stairs	20	3.6	2.0	1.6	3,760	6,016	1.3
Common Offices	72	66.0	14.4	51.6	3,760	194,016	41.3
Conference Rooms	20	15.6	9.6	6.0	3,760	22,560	4.8
Exit Signs	24	6.0	4.8	1.2	3,760	4,512	1.0
Private Offices	44	59.2	41.2	18.0	3,760	67,680	14.4
Restrooms	20	4.0	2.8	1.2	3,760	4,512	1.0
<b>Total</b>	<b>200</b>	<b>154.4</b>	<b>74.8</b>	<b>79.6</b>		<b>299,296</b>	<b>63.7</b>

Based on the collected data, the demand and energy savings are calculated:

- (a) Connected Lighting Load Reduction = 154.4 kW – 74.8 kW  
= 79.6 kW.
- (b) Interactive HVAC Demand Savings = 79.6 kW \* 0.10  
= 8.0 kW.
- (c) Total Demand Savings = (79.6 kW + 8.0 kW) \* 0.80  
= 70.1 kW.**
- (d) Lighting Energy Savings = 79.6 kW \* 3,760 hours  
= 299,296 kWh.
- (e) Interactive HVAC Energy Savings = 299,296 kWh \* 0.05  
= 14,965 kWh.
- (f) Total Energy Savings = 299,296 kWh + 14,965 kWh  
= 314,261 kWh.**

<sup>1</sup> Projects that consist of only lighting measures receive 65% of the total incentive.

## 1.3 Metered Hours Method

The **Metered Hours Method** involves monitoring a statistically significant sample of fixtures to determine post-installation operating hours. This involves developing a sampling plan to monitor the average operating hours for each lighting usage group. The Sponsor should conduct all meter installation, retrieval and data analysis.

### 1.3.1 Pre-installation M&V Activities

#### 1.3.1.1 Pre-installation equipment survey

Prior to installing the lighting retrofit, the Project Sponsor conducts a pre-installation equipment survey, to be submitted as part of the Final Application. The purpose of the pre-installation equipment survey is to inventory all existing lighting equipment, and to propose the replacement equipment to be installed. Surveys shall include all baseline lighting fixtures and controls, regardless of whether they will be retrofitted. Fixture wattages should be based on the Standard Wattage Table. This information should be organized by usage group and tabulated electronically in the Lighting Equipment Survey.

#### *Non-operating fixtures*

For non-operating fixtures, the baseline demand may be adjusted by using values from the Standard Wattage Table. **The number of non-operating fixtures will be limited to 10% of the total fixture count per facility.** If, for example, more than 10% of the total number of fixtures is inoperative, the number of fixtures beyond 10% will be assumed to have baseline fixture wattage of zero. Thus the total baseline demand for the project will be adjusted accordingly.

#### *Usage groups*

When performing the pre-installation activities associated with this M&V approach, Project Sponsors should organize the equipment into **usage groups**—collections of equipment (e.g., rooms with lighting fixtures) with similar operating schedules and functional uses. For instance, although a site's open office lighting may have the same annual hours of operation as the private office lighting, the two have different functional uses. In this case, a change in the operating hours of the private office lights due to the installation of an occupancy sensor would not be relevant to the operating hours of the open office lights. Please refer to Table 1.2 to determine the recommended minimum number of usage groups for the project site type.

**Table 1.2: Suggested minimum numbers of Usage Groups for project site types**

<b>Building Type</b>	<b>Minimum Number of Usage Groups</b>	<b>Examples of Usage Group types</b>
Office Buildings	6	General offices, private offices, hallways, restrooms, conference, lobbies, 24-hr
Education (K-12)	6	Classrooms, offices, hallways, restrooms, admin, auditorium, gymnasium, 24-hr
Education (College/University)	6	Classrooms, offices, hallways, restrooms, admin, auditorium, library, dormitory, 24-hr
Hospitals/ Health Care Facilities	8	Patient rooms, operating rooms, nurses station, exam rooms, labs, offices, hallways
Retail Stores	5	Sales floor, storeroom, displays, private office, 24-hr
Industrial/ Manufacturing	6	Manufacturing, warehouse, shipping, offices, shops, 24-hr
Other	10	N/A

**1.3.1.2 Pre-installation inspection**

Entergy or its contractor will conduct a pre-installation inspection to verify that the Sponsor has properly documented the baseline. The criterion for baseline acceptance is that the installed demand must be within  $\pm 5\%$  of the demand reported on the lighting survey form. If the error exceeds  $\pm 5\%$ , the Sponsor is allowed to resubmit corrected lighting tables. If the project fails inspection twice due to incorrect survey forms, the Project Sponsor will bear the cost of subsequent inspections. Pre-installation operating hours

The operating hours of the baseline lighting system are assumed to be the same as those of the post-retrofit lighting system and are not measured as part of the pre-installation M&V activities.

**1.3.2 Post-installation M&V Activities**

**1.3.2.1 Post-installation equipment survey**

The Sponsor is required to conduct a post-installation lighting equipment survey as part of the Installation Report. The purpose of the post-installation equipment survey is to inventory the actual, installed replacement equipment. Fixture wattages shall be based on the Standard Wattage Table. In the Installation Report, the proposed equipment information listed in the approved Final Application should be updated to reflect the actual post-retrofit conditions and equipment found during the survey after installation. Any equipment listed in the approved Final Application that was not in fact replaced should remain in the lighting equipment inventory – in this case, simply copy the pre-retrofit information to the post-retrofit columns.

**1.3.2.2 Post-installation inspection**

Entergy or its contractor will conduct a post-installation inspection to verify that the retrofit was installed as reported. In most cases, Entergy or its contractor will inspect statistically significant samples taken from the entire lighting population. The criterion for acceptance is

that the installed demand of the sample must be within  $\pm 5\%$  of the total demand submitted on the post-installation survey form. If significant errors are found that cause the error to be greater than 5%, Entergy will inform the Sponsor that the submitted lighting survey table must be corrected and resubmitted, citing the major cause of the errors found.

### 1.3.2.3 Post-Installation operating hours

After the lighting retrofit has been installed, the Project Sponsor conducts short-term metering of the operating hours for a random sample of fixtures in each usage group. As part of the FA review and approval, Entergy or their contractor can assist the Project Sponsor to randomly select the population of fixtures to be metered.

#### *Metering requirements*

For facilities with little variation in weekly operating schedules (such as offices), monitoring shall be conducted for each selected circuit for a recommended minimum of **two to four weeks** during the entire year. Monitoring should not be installed during significant holidays or vacations. If a holiday or vacation falls within the monitoring period, the duration should be extended for as many days as that holiday or vacation. For facilities such as schools, where operating hours vary seasonally, monitoring should be conducted for a minimum period during each season (i.e., in-session [fall], and out-of-session [summer]). In these cases, one of the monitoring periods should depict typical performance during the Entergy peak-demand period.

The required sample sizes for each usage group are noted in Table 1.3. Note that, because light loggers sometimes fail, over-sampling is strongly recommended. Light loggers should be calibrated prior to installation to verify that the light loggers are functioning properly.

**Table 1.3: Monitoring sample sizes\***

Population of Lines in Usage Group (n)	Sample Size
n<4	3
5≤n<8	5
9≤n<12	6
13≤n<20	7
21≤n<70	8
71≤n<300	10
n>300	11

\* Sample sizes assume a confidence interval of 80%, precision of 20%, and a coefficient of variation (cv) of 0.5 for the populations indicated.

#### *Calculation of average operating hours*

The Sponsor should extrapolate results from the monitored sample to the population to calculate the average lighting operating hours for every unique usage group. Simple, unweighted averages of operating hours should be calculated for each usage group using Equation 1.7. The Sponsor should use these average operating hours to calculate the energy savings for each respective usage group.

**Equation 1.7: Calculation of annual operating hours for a usage group**

$$Hours_{annual,u} = \frac{\sum_{i=1}^n \left[ \frac{Hours_{on,i}}{Hours_{metered,i}} * 8,760 \text{ hours/year} \right]}{n}$$

**Where:**

- $Hours_{annual,u}$  = Average annual operating hours for usage group  $u$
- $Hours_{on,i}$  = Operating hours observed during the metering period for circuit  $i$
- $Hours_{metered,i}$  = Total number of hours in the metering period for circuit  $i$
- $n$  = Number of metered circuits in usage group  $u$

Similarly, Equation 1.8 illustrates the calculation of average on-peak demand coincidence factor (CF) for a usage group. The CF multiplied by the difference in baseline and post-installation demand for each usage group, determined from the Standard Wattage Table, gives the calculate demand savings. Demand savings are only allowed for lighting fixtures that will be in operation on weekdays between the hours of 1 PM and 7 PM during the months of May through September.

**Equation 1.8: Calculation of coincidence factor for a usage group**

$$CF_u = \frac{\sum_{i=1}^n \left[ \frac{Hours_{peak\ on,i}}{Hours_{peak\ metered,i}} \right]}{n}$$

**Where:**

- $CF_u$  = Peak-demand coincidence factor for usage group  $u$
- $Hours_{peak\ on,i}$  = Equipment on-hours observed during the Entergy peak demand period during the metering period for circuit  $i$
- $Hours_{peak\ metered,i}$  = Total number of Entergy peak demand hours in the metering period for circuit  $i$
- $n$  = Number of metered circuits in usage group  $u$

**1.3.3 Calculation of Demand and Energy Savings**

The peak demand savings and energy savings are calculated according to Equations 1.1 through 1.6 in Sections 1.2.3.1 and 1.2.3.2, and Equations 1.9 and 1.10 below. The hours of operation should be calculated for each usage group and also for each season in which the usage groups' operating hours may vary (as for schools). The annual hours of operation are

determined by adding together the operating hours that are calculated for each season. If the operating hours do not vary seasonally, use one year as the “season”. Interactive HVAC demand and energy savings may be calculated only for lighting retrofits taking place in conditioned spaces. Lighting retrofits in unconditioned spaces, such as parking garages, are not eligible for interactive HVAC savings payments.

### 1.3.3.1 Hours of Operation (see Equation 1.7 above)

#### Equation 1.9:

$$\text{Seasonal Hours of Operation [hrs]} = \frac{\text{Hours Lights On}}{\text{Hours Lights Metered}} * \text{Hours in Season}$$

#### Equation 1.10:

$$\text{Annual Hours of Operation [hrs]} = \text{Sum of \{Seasonal Hours of Operation [hrs]\}}$$

### 1.3.3.2 Peak demand savings

Peak demand savings are calculated using Equations 1.1, 1.2, and 1.3 in Section 1.2.3.1.

### 1.3.3.3 Energy savings

Energy savings are calculated using Equations 1.4, 1.5, and 1.6 in Section 1.2.3.2.

### 1.3.4 Example

The following is an example of how the M&V procedures described above would be applied using the Metered Hours Method to determine the operating hours and annual energy savings.

**Example<sup>2</sup>**

A lighting efficiency project is proposed for a small, non-24-hour retail store. The Project Sponsor submits the Lighting Equipment Survey as part of the Final Application detailing the existing and proposed equipment inventory. The following table summarizes the existing and proposed connected lighting load (including calculated Coincidence Factors) for each usage group in the project, as well as the metering results and annual savings.

In this example, the operating hours are metered according to the required sample size for each usage group in the project. Because there is only one operating season, 13 light loggers are installed for one three-week period. The operating hours for each usage group are the average of observed operating hours from all meters. Using equations (a) through (g), the energy savings for *Receiving* will be

- (a) Annual Operating Hours [hrs] =  $\left\{ \left[ \frac{410}{504} \right] * 8,760 \right\}$  = **7,126 [hrs]**
- (b) Lighting Demand Savings [kW] = 9.7 [kW] – 5.4 [kW] = **4.3 [kW]**
- (c) Interactive HVAC Demand Savings [kW] = 4.3 [kW] \* 0.10 = **0.4 [kW]**
- (d) Total Demand Savings [kW] = {4.3 [kW] + 0.4 [kW]} \* 0.82 = **3.9 [kW]**
- (e) Lighting Energy Savings [kWh] = 4.3 [kW] \* 7126 [hrs] = **30,642 [kWh]**
- (f) Interactive HVAC Energy Savings [kWh] = 30,642 [kWh] \* 0.05 = **1,532 [kWh]**
- (g) Total Energy Savings [kWh] = 30,642 [kWh] + 1,532 [kWh] = **32,174 [kWh]**

The energy savings is then calculated for each usage group.

Usage Group	Equation Solutions						
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
<b>Receiving</b>	<b>7,126</b>	<b>4.3</b>	<b>0.4</b>	<b>3.9</b>	<b>30,642</b>	<b>1,532</b>	<b>32,174</b>
Continuous	8,760	0.2	0.0	0.2	1,752	88	1,840
Admin. Offices	3,024	0.6	0.1	0.5	1,814	91	1,905
Restrooms	2,120	0.5	0.1	0.5	1,060	53	1,113
Sales Floor	5,840	13.3	1.3	10.8	77,672	3884	81,556
<b>Total</b>				<b>15.9</b>			<b>118,588</b>

<sup>2</sup>Projects that consist of only lighting receive 65% of the total incentive.