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M&V Guidelines for New Construction Lighting Efficiency Measures

1.1 Overview

This M&V procedure is intended for use with lighting efficiency measures in new construction projects. Lighting efficiency measures must include the installation of high-efficiency lamps and ballasts. Installed lighting technologies must be at least as efficient as T-8s with electronic ballasts and compact fluorescent light bulbs. T-12s and incandescent light bulbs are not eligible for the program.

This M&V procedure is not intended for use with lighting controls measures. Projects with daylighting controls or occupancy controls measures will be handled on a case-by-case basis. The Project Sponsor should work with CenterPoint Energy to develop appropriate M&V procedures.

Demand savings are based on coincident load factors and a project's installed interior lighting load (Watts), compared to the product of the maximum, code-allowed lighting power density (W/ft²) for the type of building and the illuminated floor area (ft²). Energy savings are determined by multiplying the project's demand savings by the average operating hours for the building.

The installed interior lighting load is determined using lighting fixture wattage values from the Table of Standard Fixture Wattages. The Project Sponsor should establish operating hours using one of the following methods:

Stipulated Hours Method – Energy savings are based on whole building stipulated operating hours established for certain building types (See Table 1.2).

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

The method selected and the rigor of the M&V activities are functions of the project site characteristics and the savings potential.

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.

The Project Sponsor is required to submit a pre-installation equipment specification sheet, detailing the fixtures planned for the building, and a post-installation equipment survey detailing the fixtures actually installed. The Project Sponsor should fill out and submit survey results in the standard New Construction Lighting Equipment Survey using fixture codes provided in the Table of Standard Fixture Wattages. CenterPoint Energy or its

contractor will conduct a post-installation inspection to verify the installation of the specified equipment.

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 types listed in Table 1.2. The Stipulated Hours Method may only be used for those building types listed in Table 1.2, without exception. Buildings of types not listed in Table 1.2 are required to use the Metered Hours Method of M&V.

1.2.1 Pre-Installation M&V Activities

1.2.1.1 Pre-Installation Equipment Specification

Prior to installing the lighting measures, the Project Sponsor prepares a pre-installation equipment specification sheet by filling out a New Construction Lighting Equipment Survey form. The Project Sponsor submits this information as part of the Final Application. The pre-installation equipment specification should provide the following information about all proposed fixtures: room location, fixture, lamp, and ballast types, area designations, counts of fixtures, and type of control device. Surveys should include all proposed lighting fixtures and controls. The Project Sponsor must include estimates of the amount of lighting that will be provided by task lamps and other moveable lighting sources. Fixture wattages are based on the fixture codes listed in the Table of Standard Fixture Wattages. This information should be tabulated electronically in the New Construction Lighting Equipment Survey form. Once the Project Sponsor enters all fixtures into the form, the form calculates what the building's installed interior lighting load will be.

Some types of lighting fixtures are exempt from inclusion in the interior lighting demand calculation. Project Sponsors should list exempt fixtures in the separate sheet provided in the New Construction Lighting Equipment Survey form. Exempt fixtures are fixtures that provide lighting that is in addition to general, ambient lighting, have separate control devices, and are installed in one of the following applications¹:

- Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments.
- Lighting that is integral to equipment or instrumentation and is installed by its manufacturer.
- Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical equipment.
- Lighting integral to both open and glass enclosed refrigerator and freezer cases.
- Lighting integral to food warming and food preparation equipment.

¹ Reference: ASHRAE 90.1-1999, Section 9.3.1.

- Lighting for plant growth or maintenance.
- Lighting in spaces specifically designed for use by the visually impaired.
- Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
- Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
- Lighting that is an integral part of advertising or directional signage.
- Exit signs.
- Lighting that is for sale or lighting educational demonstration systems.
- Lighting for theatrical purposes, including performance, stage, and film and video production.
- Athletic playing areas with permanent facilities for television broadcasting.
- Casino gaming areas.

1.2.2 Post-Installation M&V Activities

1.2.2.1 Post-Installation Equipment Survey

The Project 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 equipment. Inventory information should be tabulated electronically in the New Construction Lighting Equipment Survey. Fixture wattages shall be based on the Table of Standard Fixture Wattages. Once the Project Sponsor enters all fixtures into the Survey form, the form calculates the building's installed interior lighting load.

1.2.2.2 Post-Installation Inspection

CenterPoint Energy or its contractor will conduct a post-installation inspection to verify that the measures were installed as reported. In most cases, CenterPoint Energy 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 $\pm 5\%$, CenterPoint Energy will inform the Project Sponsor that the submitted lighting survey must be corrected and resubmitted, citing the major cause of the errors found.

1.2.2.3 Lighting Power Allowance

Demand savings are based on the difference between a project's installed lighting load, compared to the maximum, code-specified lighting power allowance. To calculate the

maximum code-allowed lighting power allowance for a building, multiply the maximum lighting power density for the appropriate building type, as listed in Table 1.1, by the gross lighted floor area of the building. If a lighting measure is planned for a building type not listed in Table 1.1, choose the building type that is most similar in function. If a lighting measure is planned for a building with mixed usages, e.g. a high rise building with retail space and office space, choose the building type that represents the largest portion of the floor space.

Table 1.1 Lighting Power Densities by Building Type²

Building Type	Lighting Power Density (W/ft ²)		Building Type (cont.)	Lighting Power Density (W/ft ²)
Automotive facility	1.5		Museum	1.6
Convention Center	1.4		Office	1.3
Court House	1.4		Parking Garage	0.3
Dining: Bar Lounge/Leisure	1.5		Penitentiary	1.2
Dining: Cafeteria/Fast Food	1.8		Performing Arts Theater	1.5
Dining: Family	1.9		Police/Fire Station	1.3
Dormitory	1.5		Post Office	1.6
Exercise Center	1.4		Religious Building	2.2
Gymnasium	1.7		Retail	1.9
Hospital/Health Center	1.6		School/University	1.5
Hotel	1.7		Sports Arena	1.5
Library	1.5		Town Hall	1.4
Manufacturing Facility	2.2		Transportation	1.2
Motel	2.0		Warehouse	1.2
Motion Picture Theater	1.6		Workshop	1.7
Multi-Family	1.0			

1.2.2.4 Operating Hours

The **Stipulated Hours Method** uses pre-calculated annual operating hours and coincidence factors as listed in Table 1.2. 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.

² Reference: ASHRAE 90.1-1999, Table 9.3.1.1.

Table 1.2: 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
24-Hour Supermarket/Retail	6,900	95%	10%	5%
College/University	2,085	67%	10%	5%
Education (K-12; no summer session)	2,150	82%	10%	5%
In-Patient Health Care	3,750	60%	10%	5%
Multi-Family Housing, Common Areas	4,772	87%	10%	5%
Non 24-Hour Supermarket/Retail/Restaurant	4,250	95%	10%	5%
Office	3,760	80%	10%	5%
Parking Structure	7,884	100%	0%	0%

The first column in Table 1.2 presents the stipulated, whole-building, annual operating hours for the building types listed. The energy savings are determined from the operating hours and the kW reduction determined from the New Construction Lighting Equipment Survey form. 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 on-peak hours during the monitoring period. The demand savings are determined from the CF and the kW reduction determined from the Table of Standard Fixture Wattages.

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 1.2. The CF is used to adjust total installed lighting demand for the actual percentage of fixtures operating during CenterPoint Energy’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 installations that occur in air-conditioned spaces. Lighting measures installed 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:

$$\text{Connected Lighting Load Reduction [kW]} = (\text{Lighting Power Density [W/ft}^2\text{]} * \text{Gross Lighted Floor Area [ft}^2\text{]} * .001 [\text{kW/W}]) - \text{Installed Interior Lighting Load [kW]}$$

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:

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

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

High-efficiency lighting systems are proposed for a small office building project scheduled for construction in the next year. The office building will have a gross lighted floor area of 70,251 ft². The Project Sponsor submits the lighting equipment specification sheet as part of the Final Application, detailing the proposed equipment. The table below summarizes the proposed interior lighting load for each usage group in the project. The code-specified maximum lighting power density for offices is 1.3 W/ft². The CF for office buildings is **80%**.

Area Description	Survey Lines	Proposed Interior Lighting Load (kW)	Stipulated Operating Hours
Hallways and Stairs	20	2.0	3,760
Common Offices	72	14.4	3,760
Conference Rooms	20	9.6	3,760
Task Lamps	24	4.8	3,760
Private Offices	44	41.2	3,760
Restrooms	20	2.8	3,760
Total	200	74.8	

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

- (a) Connected Lighting Load Reduction = $(1.3 \text{ W/ft}^2 * 70,251 \text{ ft}^2 * .001 \text{ kW/W}) - 74.8 \text{ kW}$
= 16.5 kW
- (b) Interactive HVAC Demand Savings = $16.5 \text{ kW} * 0.10$
= 1.7 kW
- (c) Total Demand Savings = $(16.5 \text{ kW} + 1.7 \text{ kW}) * 0.80$
= 14.6 kW**
- (d) Lighting Energy Savings = $16.5 \text{ kW} * 3,760 \text{ hours}$
= 62,040 kWh
- (e) Interactive HVAC Energy Savings = $62,040 \text{ kWh} * 0.05$
= 3,102 kWh
- (f) Total Energy Savings = $62,040 \text{ kWh} + 3,102 \text{ kWh}$
= 65,142 kWh**

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 Project 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 measures, the Project Sponsor prepares a pre-installation equipment specification sheet by filling out a New Construction Lighting Equipment Survey form. The Project Sponsor submits this information as part of the Final Application. The pre-installation equipment specification should provide the following information about all proposed fixtures: room location, fixture, lamp, and ballast types, area designations, counts of fixtures, and type of control device. Surveys should include all proposed lighting fixtures and controls. The Project Sponsor must include estimates of the amount of lighting that will be provided by task lamps and other moveable lighting sources. Fixture wattages are based on the fixture codes listed in the Table of Standard Fixture Wattages. This information should be tabulated electronically in the New Construction Lighting Equipment Survey form. Once the Project Sponsor enters all fixtures into the form, the form calculates what the building's installed interior lighting load will be.

Some types of lighting fixtures are exempt from inclusion in the interior lighting demand calculation. Project Sponsors should list exempt fixtures in the separate sheet provided in the New Construction Lighting Equipment Survey form. Exempt fixtures are fixtures that provide lighting that is in addition to general, ambient lighting, have separate control devices, and are installed in one of the following applications³:

- Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments.
- Lighting that is integral to equipment or instrumentation and is installed by its manufacturer.
- Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical equipment.
- Lighting integral to both open and glass enclosed refrigerator and freezer cases.
- Lighting integral to food warming and food preparation equipment.
- Lighting for plant growth or maintenance.

³ Reference: ASHRAE 90.1-1999, Section 9.3.1.

- Lighting in spaces specifically designed for use by the visually impaired.
- Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
- Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
- Lighting that is an integral part of advertising or directional signage.
- Exit signs.
- Lighting that is for sale or lighting educational demonstration systems.
- Lighting for theatrical purposes, including performance, stage, and film and video production.
- Athletic playing areas with permanent facilities for television broadcasting.
- Casino gaming areas.

Usage Groups

When compiling the equipment specification form, 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 restroom lighting may have the same annual hours of operation as the open office lighting, the two have different functional uses and should be classified in separate usage groups. Please refer to Table 1.3 to determine the recommended minimum number of usage groups for the project site type.

Table 1.3: Suggested minimum numbers of Usage Groups for project site types

Building Type	Minimum Number of Usage Groups	Examples of Usage Group types
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

1.3.2 Post-Installation M&V Activities

1.3.2.1 Post-Installation Equipment Survey

The Project 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 equipment. Inventory information should be tabulated electronically in the New Construction Lighting Equipment Survey. Fixture wattages shall be based on the Table of Standard Fixture Wattages.

1.3.2.2 Post-Installation Inspection

CenterPoint Energy or its contractor will conduct a post-installation inspection to verify that the specified equipment was installed as reported. In most cases, CenterPoint Energy 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%, CenterPoint Energy will inform the Project 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 equipment has been installed and the facility is occupied, 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, CenterPoint Energy 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 peak-demand period.

The required sample sizes for each usage group are noted in Table 1.4. Note that, because light loggers sometimes fail, over-sampling is strongly recommended. Light loggers should be tested prior to installation to verify that the light loggers are functioning properly.

Table 1.4: 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 Project 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 Project 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

After calculating annual operating hours for each usage group, the Project Sponsor can calculate annual operating hours for the whole building. The annual operating hours for the whole building are equal to the average of the operating hours for each usage group, weighted by the installed lighting demand of each usage group.

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 Table of Standard Fixture Wattages, 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 peak demand period during the metering period for circuit i
- $Hours_{peak\ metered,i}$ = Total number of peak demand hours in the metering period for circuit i
- n = Number of metered circuits in usage group u

After calculating coincidence factors for each usage group, the Project Sponsor can calculate an average coincidence factor for the whole building. The coincidence factor for the whole building is equal to the average of the coincidence factors for each usage group, weighted by the installed lighting demand of each usage group.

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, 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 installed in conditioned spaces. Lighting in unconditioned spaces, such as parking garages, is not eligible for interactive HVAC savings payments.

1.3.3.1 Hours of Operation (see Equation 1.7 above)

Equation 1.9:

$\text{Seasonal Hours of Operation [hrs]} = \frac{\text{Hours Lights On}}{\text{Hours Lights Metered}} * \text{Hours in Season}$
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Equation 1.10:

$\text{Annual Hours of Operation [hrs]} = \text{Sum of \{Seasonal Hours of Operation [hrs]\}}$
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1.3.3.2 Peak Demand Savings

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

1.3.3.3 Energy Savings

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

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

A 80,000 ft², 24-hour warehouse was constructed with highly efficient lighting systems. The Project Sponsor submits the Lighting Equipment Survey as part of the Installation Report, detailing the installed equipment. The following table summarizes the connected lighting load (including calculated Coincidence Factors) for each usage group in the project, as well as the metering results. In this example, the operating hours are metered according to the required sample sizes for each usage group in the project. Because there is only one operating season, the 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.

Area Description	Connected Lighting Load (kW)	Measured Operating Hours	Measured Coincidence Factor
Receiving	2.0	[188/504] * 8,760 = 3,268	[19/90] = 0.21
Admin. Offices	14.4	[106/504] * 8,760 = 1,842	[23/90] = 0.26
Restrooms	9.6	[225/504] * 8,760 = 3,911	[38/90] = 0.42
Shop	4.8	[314/504] * 8,760 = 5,458	[44/90] = 0.49
Continuous	41.2	[410/504] * 8,760 = 7,126	[60/90] = 0.67
Total	72.0	Weighted Avg. = 5,422	Weighted Avg. = 0.53

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

- (a) Connected Lighting Load Reduction = $(1.2 \text{ W/ft}^2 * 80,000 \text{ ft}^2 * .001 \text{ kW/W}) - 72.0 \text{ kW}$
= 24.0 kW
- (b) Interactive HVAC Demand Savings = $24.0 \text{ kW} * 0.10$
= 2.4 kW
- (c) Total Demand Savings = $(24.0 \text{ kW} + 2.4 \text{ kW}) * 0.53$
= 14.0 kW**
- (d) Lighting Energy Savings = $24.0 \text{ kW} * 5,422 \text{ hours}$
= 130,128 kWh
- (e) Interactive HVAC Energy Savings = $130,128 \text{ kWh} * 0.05$
= 6,506 kWh
- (f) Total Energy Savings = $130,128 \text{ kWh} + 6,506 \text{ kWh}$
= 136,634 kWh**

