NATIONAL RENEWABLE ENERGY LABORATORY

Chapter 2: Commercial and Industrial Lighting Evaluation Protocol

The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures

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1 Measure Description

The Commercial and Industrial Lighting Evaluation Protocol (the protocol) describes methods to account for energy savings resulting from the programmatic installation of efficient lighting equipment in large populations of commercial, industrial, and other nonresidential facilities. This protocol does not address savings resulting from changes in codes and standards or from education and training activities. A separate “Lighting Controls Evaluation Protocol” addresses methods for evaluating savings resulting from lighting control measures such as adding time clocks, tuning energy management system commands, and adding occupancy sensors.

Historically, lighting equipment has accounted for a significant portion of cost-effective, electric energy efficiency resources in the United States, a trend likely to continue as old technologies improve and new ones emerge. By following the methods presented here, the energy savings from lighting efficiency programs in different jurisdictions or regions can be measured uniformly, providing planners, policymakers, regulators, and others with sound, comparable data for comprehensive energy planning. Also, the methods here can be scaled to match the evaluation costs to the value of the resulting information.[1]

An energy efficiency measure is defined as a set of actions and equipment changes that result in reduced energy use—compared to standard or existing practices—while maintaining the same or improved service levels for customers or processes. Energy-efficient lighting measures in existing facilities deliver the light levels (illuminance and spatial distribution) required for activities or processes at reduced energy use, compared to original or baseline conditions. In new construction, “original or baseline condition” usually refers to the building codes and standards in place at the time of construction.

Examples of energy-efficient lighting measures in commercial, industrial, and other nonresidential facilities include:

- Retrofitting existing, linear, fluorescent fixtures with efficacious[2] lamps and ballasts, or delamping overlit spaces
- Replacing incandescent lamps with compact fluorescent lamps
- Replacing high-bay fixtures (such as metal halide or linear fluorescent) with efficacious high-bay equipment (such as light-emitting diodes or high-performance linear fluorescents).

In practice, lighting retrofit projects and new construction projects commonly implement lighting fixture and lighting controls measures concurrently. This protocol accommodates these mixed measures.

1 As discussed in the section “Considering Resource Constraints” of the Introduction chapter to this report, small utilities (as defined under U.S. Small Business Administration regulations) may face additional constraints in undertaking this protocol. Therefore, alternative methodologies should be considered for such utilities.

2 Efficiency of lighting equipment is expressed as “efficacy,” in units of lumens per Watt, where lumens are a measure of light output.

2 Application Conditions of the Protocol

Energy efficiency lighting programs result in the installation of commercial, industrial, and nonresidential lighting measures in customer facilities. The programs can take advantage of varying delivery mechanisms, depending on target markets and customer types. Primarily, these mechanisms can be distinguished by the parties receiving incentive payments from a program. Although the methods this protocol describes apply to all delivery mechanisms, issues with customer and baseline equipment data vary with each.

2.1 Common Program Types

The following are descriptions of common program types used to acquire lighting energy and demand savings and their associated data issues.

2.1.1 Incentive and Rebate

Under this model, implementers pay program participants in target markets to install lighting measures. A participants receives either an incentive payment, based on savings ($/kilowatt-hour [kWh]), or a rebate for each fixture or lamp ($/fixture, $/lamp). The terms incentive and rebate sometimes are used interchangeably, but generally, incentives are calculated based on project savings and rebates are based on equipment installed. Examples of participants include contractors, building owners, and property managers.

Savings can be estimated using simple engineering calculations. Some programs include a measurement and verification (M&V) process, in which key parameters—such as hours of use (HOU), baseline, and retrofit fixture wattages—are verified or measured, or both, as part of project implementation.

Rebate programs typically pay for specific lighting equipment types (for example, a 4-foot, four-lamp, T5 electronic ballast fixture), often after they have been installed, so assumptions must be made about baseline or replaced equipment. The result is a tradeoff: increased administrative efficiency for less certainty about baseline conditions (and therefore, savings).

Incentive programs often collect more detailed baseline data than do rebate programs. Typically, these data include baseline and retrofit equipment wattages and HOUs, which facilitate determination of savings impacts.

Although rebate programs typically track useful information about replacement lighting equipment, they may not collect baseline data.

2.1.2 Upstream Buy-Down

In upstream buy-down scenarios, programs pay incentive dollars to one or more entities (such as retail outlets, distributors, or manufacturers) in the lighting equipment market distribution chain. Although residential equipment programs commonly use the upstream buy-down program delivery approach, particularly for compact fluorescent lamps, commercial and industrial lighting programs use it less often.

Upstream buy-down programs do not interact with the end-use customers purchasing energy-efficient equipment; thus, baseline conditions and installation rates cannot be known. Program planners, implementers, and impact evaluators estimate these parameters based on their experience with other programs or targeted market research studies.

2.1.3 Direct Install

Under this delivery approach, contractors, acting on a program's behalf, install energy-efficient lighting equipment in customer facilities. The programs pay contractors directly. Customers receive a lighting retrofit at reduced cost. Direct-install programs often target hard-to-reach customers—typically small businesses—that are overlooked by contractors working with incentive and rebate programs.

Direct-install programs can usually collect precise information about baseline and replacement equipment, and the program implementers may have reasonable estimates of annual operating hours. Data, when collected, can be used directly by impact evaluation researchers.

2.2 Program Target Markets

In addition to being distinguished by their delivery mechanisms, commercial, industrial, and non-residential lighting programs can be classified by targeting retrofits (serving existing facilities) and new construction markets. Program delivery types described above apply to retrofit programs. New construction programs also employ incentives and rebates (and customers may benefit from upstream buy-downs) to improve lighting energy efficiency.

New construction programs present evaluators with a dilemma in establishing baselines for buildings that have yet to be built. The problem is addressed by referring to new construction energy codes for commercial, industrial, and nonresidential facilities (usually by referencing IECC or ASHRAE Standard 90.1). The codes define lighting efficiency, primarily in terms of lighting power density (lighting watts/ft^2), calculated using simple spreadsheets. Other federal, state, and local standards may set additional baseline constraints on lamps, ballasts, and fixture efficiency/efficacy.

3 Savings Calculations

Project and program savings for lighting and other technologies result from the difference between the energy consumption that would have occurred had the measure not been implemented (the baseline) and the consumption occurring after the retrofit. Energy calculations use the following fundamental equation:

Energy Savings = (Baseline-Period Energy Use – Reporting-Period Energy Use) ± Adjustments

The equation's adjustment term calibrates baseline or reporting use and demand to the same set of conditions. Common adjustments account for changes in schedules, occupancy rates, weather, or other parameters that can change between baseline and reporting periods. Adjustments commonly apply to heating, ventilating, and air-conditioning (HVAC) measures, but less commonly to lighting measures, or are inherent in algorithms for calculating savings.

Regulators and program administrators may require that lighting energy efficiency programs report demand savings *and* energy savings. Demand calculations use the following fundamental equation:

Demand Savings = (Baseline-Period Demand – Reporting-Period Demand) ± Adjustments

Demand savings, which is calculated for one or more time-of-use periods, is typically reported for the peak period of the utility system serving the efficiency program customers.

3.1 Algorithms

The following equations calculate first-year energy and demand on-site savings for lighting measures in commercial, industrial, nonresidential facilities:

3.1.1 Energy Savings

Equations in this section are used to calculate first-year energy savings for lighting measures.

Equation 1. Lighting Electric Energy Savings

$$kWh\ Save_{light} = \sum_{u,i}\left(\frac{fix\ watt_{base,i} \cdot qty_{base,i}}{1000} \cdot HOU_{base}\right)_u - \sum_{u,i}\left(\frac{fix\ watt_{ee,i} \cdot qty_{ee,i}}{1000} \cdot HOU_{ee}\right)_u$$

where:

kWh Save $_{light}$ = Annual kWh savings resulting from the lighting efficiency project

fix watt $_{base, ee, i}$ = Fixture wattage, baseline or energy-efficient, fixture type i

qty $_{base, ee, i}$ = Fixture quantity, baseline or energy-efficient, fixture type i

u = Usage group, a collection of fixtures sharing the same operating hours and schedules, for example all fixtures in office spaces or hallways

HOU $_{base, ee}$ = Annual hours of use, baseline or energy-efficient, usually assumed unchanged from baseline unless new controls are installed

Equation 2. Interactive Cooling Energy Savings for Interior Lighting

$$kWh\ Save_{interact-cool} = kWh\ Save_{light} \cdot IF_{kWh,c}$$

Equation 3. Interactive Heating Energy Savings for Interior Lighting

$$kWh\ Save_{interact-heat} = kWh\ Save_{light} \cdot IF_{kWh,h}$$

where:

kWh Save $_{interact\text{-}cool}$ = Interactive cooling energy impact due to a lighting efficiency project

kWh Save $_{interact\text{-}heat}$ = Interactive heating energy impact from a lighting efficiency project

IF $_{kWh,c}$ = Interactive cooling factor: the ratio of cooling energy reduction per unit of lighting energy reduction resulting from the reduction in lighting waste heat removed by an HVAC system

IF $_{kWh,h}$ = Interactive heating factor: the ratio of heating energy increase per unit of lighting energy resulting from reduction in lighting waste heat that must be supplied by an HVAC system during the heating season

Note that interactive effects apply only to interior lighting that operates in mechanically heated or cooled spaces.

Equation 4. Total Annual Energy Savings Due to Lighting Project

$$kWh\ Save_{total=}kWh\ Save_{light} + kWh\ Save_{interact-cool} + kWh\ Save_{interact-heat}$$

3.2 Electric Peak Demand Savings

The equations in this section are used to calculate first-year electric peak demand savings for lighting measures. Additional information is available in the UMP document “Peak Demand and Time-Differentiated Energy Savings.”

Equation 5. Lighting Electric Peak Demand Savings

$$kW\ Peak\ Save_{light} = CF \cdot \sum_{u,i} \left(\frac{fix\ watt_{base,i} \cdot qty_{base,i}}{1000} - \frac{fix\ watt_{ee,i} \cdot qty_{ee,i}}{1000} \right)_u$$

where:

CF = coincidence factor, the fraction (0.0 to 1.0) of connected lighting load turned on during a utility peak period

Equation 6. Interactive Electric Cooling Demand Savings for Interior Lighting

$$kW\ Peak\ Save_{interact-cool} = \ kW\ Save_{light} \cdot IF_{kW,c}$$

where:

kilowatt (kW) Peak Save $_{\text{interact-cool}}$ = Interactive electric cooling demand impact from a lighting efficiency project

IF $_{\text{kW,c}}$ = Interactive cooling factor, ratio of cooling demand reduction per unit of lighting demand reduction during the peak period resulting from the reduction in lighting waste heat removed by an HVAC system

Interactive effects apply only to interior lighting operating in mechanically cooled spaces. Interactive heating effects are usually ignored in North America because heating equipment is typically nonelectric and heating demand is usually not coincident with utility system peaks.

Equation 7. Total Electric Peak Demand Savings Due to Lighting Project

$$kW\ Peak\ Save_{total=}kW\ Peak\ Save_{light} + kW\ Peak\ Save_{interact-cool}$$

4 Role of the Lighting Program Implementer

Successful application of this protocol requires collecting standard data in a prescribed format as part of the implementation process. The protocol further requires tracking project and program savings estimated on the basis of those standard data.

The implementer is responsible for ensuring necessary data are collected to track program activity and to calculate savings at the project level. The implementer is responsible for maintaining a program activity record, including anticipated savings by project.

4.1 Program Implementer Data Requirements

The protocol recommends the program implementer collect and archive, for all projects, all data needed to execute the savings algorithms. These data are:

- Baseline fixture inventory, including fixture wattage
- Baseline fixture quantities
- Baseline lighting HOU
- Efficient fixture inventory, including wattage
- Efficient fixture quantities
- Efficient lighting HOU
- Usage group assignments
- Heating and cooling equipment types
- Interactive factor for cooling (optional)
- Interactive factor for heating (optional)

Facilities—or spaces within facilities where the project is installed—are classified as cooled/uncooled or heated/unheated, so it is important to record information about heating and cooling equipment and fuel types for each facility or space. This information is used to estimate interactive effects.

4.2 Implementation Data Collection Method

The protocol recommends participants collect and submit required data as a condition for enrolling in the program. The protocol also recommends the implementer specify the data reporting format, either by supplying a structured form (such as a spreadsheet) or by specifying the data fields and types used when submitting material to the program.

The format of the data must be electronic, searchable, and sortable. It must also support combining multiple files into single tables for analysis by the implementer. Microsoft Excel and comma-separated text files are acceptable formats; however, faxes, PDFs, and JPEGs do not meet these criteria.

The data reporting format should be structured to allow verification of the project installation. Each record or line in the report: (1) is a collection of identical fixture types, (2) is installed in an easily located room, floor, or space, and (3) belongs to one usage group. Table 1 lists the fields required in the data reporting format. All data are supplied by the participant.

Table 1: Required Lighting Data Form Fields

Field	Notes
Location	Floor number, room number, description
Usage group	
Location heating	Yes/no
Location heating type	Boiler steam/hydronic, rooftop gas-fired, etc.
Location heating fuel	Electric, natural gas, fuel oil, etc.
Location cooling	Yes/no
Location cooling type	Water cooled chiller, air cooled chiller, packaged DX, etc.
Location cooling fuel	Electric, natural gas, etc.
Baseline fixture type	From lookup table supplied by implementer, manufacturer cut sheet
Baseline fixture count	
Baseline fixture watt	From lookup table supplied by implementer, manufacturer cut sheet
Baseline HOU	From lookup table supplied by implementer, estimated by customer, BMS or meter data
Efficient fixture type	From lookup table supplied by implementer, manufacturer cut sheet
Efficient fixture count	
Efficient fixture watt	From lookup table supplied by implementer, manufacturer cut sheet
Efficient lighting HOU	Same as baseline if no controls installed
IF_c	Interactive factor for cooling, from lookup table, optional
IF_h	Interactive factor for heating, from lookup table, optional
kWh_{save}	Calculated using savings algorithms

The Appendix to this protocol contains an example of a lighting inventory form with the fields listed in Table 1.

5 Role of the Evaluator

The evaluator's role is to determine energy savings resulting from the operation of lighting efficiency programs. The steps in this procedure include:

1. Reviewing a sample of completed projects, including conducting on-site M&V activities
2. Calculating a realization rate (the ratio of evaluator-to-implementer anticipated savings)
3. Using the realization rate to adjust the implementer-estimated savings.

5.1 Evaluator Data Requirements

The protocol recommends the program evaluator collect the same data as the implementer. As described in the M&V Plan, the evaluator must have access to the implementation lighting inventory forms and participant application material for each project in the sample.

5.2 Evaluator Data Collection Method

Under the protocol, the implementer provides the evaluator with a copy of the program and project data tracking record for the evaluation review period. That record contains the fields specified in Table 1. The implementer also provides all records for projects in the evaluation review sample, including application materials and site contact information.

The protocol recommends the evaluator collect additional M&V data during site visits conducted for the sample of evaluation review projects. Table 2 lists data required for each project in the evaluation sample.

Table 2: Lighting Data Required by Evaluator

Field	Note
Location	From implementer
Usage group	From implementer
Location heating	From implementer, verified by evaluator
Location heating type	From implementer, verified by evaluator
Location heating fuel	From implementer, verified by evaluator
Location cooling	From implementer, verified by evaluator
Location cooling type	From implementer, verified by evaluator
Location cooling fuel	From implementer, verified by evaluator.
Baseline fixture type	From implementer, verified by evaluator
Baseline fixture count	From implementer, verified by evaluator
Baseline fixture watt	From implementer, verified by evaluator
Baseline HOU	From implementer, verified by evaluator
Efficient fixture type	From implementer, verified by evaluator
Efficient fixture count	From implementer, verified by evaluator
Efficient fixture watt	From implementer, verified by evaluator
Efficient lighting HOU	Measured by evaluator
IF_c	Interactive factor for cooling, from lookup table, optional
IF_h	Interactive factor for heating, from lookup table, optional
kWh_{save}	Calculated using savings algorithms

6 Measurement and Verification Plan

The M&V plan describes how evaluators determine actual energy savings in a facility where a lighting efficiency project has been installed. Evaluators use M&V to establish energy savings for projects. The M&V results are applied to the population of all completed projects to determine program savings. The sampling and application processes are described in Chapter 11: *Sample Design*.

All M&V activities in the protocol are conducted on a representative sample of completed projects, drawn from a closed reporting period (for example, a program year).

6.1 IPMVP Option

The protocol recommends evaluators conduct M&V according to the International Performance Measurement and Verification Protocol (IPMVP) Option A—Retrofit Isolation: Key Parameter Measurement approach.

The key measured parameters are the HOU terms in Equation 1. The fixture quantity parameter is verified through an inspection process. The fixture wattage parameter is verified through a combination of on-site inspections and look-up tables of fixture demand (Watts).

Option A is recommended because the demand (Watts) values are known and published for nearly all fixture types and configurations, and therefore need not be measured, whereas lighting operating hours vary widely from building to building.

6.2 Verification Process

Verification involves visual inspections and engineering calculations to establish an energy efficiency project's potential to achieve savings. The verification process determines the fixture wattage and fixture quantity parameters in Equation 1.

A description of the activities involved in the process follows these steps:

1. Select a representative sample of projects for review. (See Chapter 11: *Sample Design* for guidance on sampling.)
2. Schedule a site visit with a facility representative for each project in the sample.
3. Conduct an on-site review for each project. Inspect a representative sample of the energy efficiency lighting fixtures reported by the implementer. (See Sample Design chapter for guidance on sampling.)
4. Confirm or correct the reported energy-efficient fixture type and wattage for each fixture in the sample.
5. Confirm or correct the reported quantity for all energy-efficient fixtures in the sample.
6. Confirm or correct the heating/cooling status and associated equipment for the spaces in the sample.
7. Interview facility representatives to check baseline fixture types and quantities reported for the sample. Confirmation or correction is based on the interviews. When available, interviews are supplemented by physical evidence, such as: fixture types in

areas not changed by the project, replacement stock for lamps and ballasts, and/or stockpiles of removed fixtures stored on-site for recycle or disposal.

8. Update lighting inventory form for the sample, based on findings from the on-site review.

At the completion of the verification process, the evaluator has confirmed or corrected the fixture wattage and fixture quantity parameters in Equation 1. The process for determining the HOU parameters is described in the following section.

6.3 Measurement Process

The measurement process involves using electronic metering equipment to collect the data for determining the HOU parameters in Equation 1. Most often, the equipment is installed temporarily during the measurement period; however, some facilities have energy management systems that monitor lighting circuits, and these may be employed.

Metering equipment used to measure lighting operating hours either records a change of state (light on, light off) or continuously samples and records current in a lighting circuit or light output of a fixture. All data must be time-stamped for application in the protocol.

6.3.1 Use of Data Loggers

Lighting operating hours are typically determined through the use of temporary equipment such as data loggers.

Change-of-state lighting data loggers are small (matchbox size) integrated devices, which include a photocell, a microprocessor, and memory. The data logger is mounted temporarily inside a fixture (or in proximity to it) and is calibrated to the light output of the fixture. Each time the lamp(s) in the fixture are turned on or off, the event is recorded and time-stamped.

Data loggers that continuously sample and record lighting operating hour information usually require an external sensor such as a current transformer (CT) or photocell. Data loggers with CTs can monitor amperage to a lighting circuit. Spot measurements of the circuit's amperage with the lights on and off establish the threshold amperage for the on condition. Similarly, a data logger with an external photocell can record light levels in a space. Spot measurements of lumen levels with the fixtures on and off establish the light level threshold for the on condition.

Although measuring amperage with data loggers is common, the continuous monitoring of light levels to determine hours of operation is less common.

Data logger failure commonly occurs due to incorrect adjustments, locations, or software launch. Thus, this protocol recommends following manufacturer recommendations carefully.

6.3.2 Metering

The measurement process involves metering lighting operating hours for the representative sample of fixtures selected for the verification process. Meters are deployed (or routines are programmed in an existing energy management system) during the verification site visit.

This process entails the following activities:

1. Meter operating hours for each circuit in the verification sample.
    A. If using light loggers, deploy loggers in one or more fixtures controlled by the circuit. Only one logger is required per circuit; additional loggers may be deployed to offset logger failure or loss.
    B. If measuring amperage, install CT and data logger in a lighting panel for a sampled circuit. The sampling interval should be 15 minutes or less. Spot-measure amperage with lights on and off for the circuit leg with CT. Record the amperage threshold for the lights-on condition.
    C. If using an energy management system, program trends for lighting on/off status for each circuit in the sample. The sampling interval should be 15 minutes or less. Check that the energy management system has sufficient capacity to archive recorded data, and that the metering task will not adversely slow system response times.
2. Check data logger operation. Before leaving the site, spot-check a few data loggers to confirm they are recording data as expected. Correct any deficiencies and if the deficiencies appear to be systemic, redeploy the loggers. If using energy management system trends, spot-check recorded data.
3. Leave the metering equipment in place for the duration of the monitoring period. The protocol recommends a monitoring period that captures the full range of facility operating schedules.
    A. For facilities with constant schedules (such as office buildings, grocery stores, and retail shops), the protocol requires metering for a minimum of two weeks.
    B. For facilities with variable or irregular schedules, additional metering time is required. The protocol recommends a monitoring period long enough to capture the average operation over the full range of variable schedules.
    C. Facilities with seasonal schedules, such as schools, should be monitored during active periods; additional monitoring can be done during the inactive periods, or if the expected additional savings are small, the hours can be estimated as a percent of active period hours.
4. Analyze metering data. Calculate the percentage of "on" time (percent on-time) for the metered lighting equipment for each usage group. Percent on-time is the number of hours the lighting equipment is on divided by the total number of hours in the metering period.
    A. For facilities with constant or variable schedules, the HOU parameter is calculated as: 8,760 hours/year, less any hours when the facility is closed for holidays, times the percent-on time.
    B. For facilities with seasonal schedules, the HOU parameter is: the hours/year in the active period, times the percent-on time.
    C. The data used in the analysis should represent a typical schedule cycle, for example; 7, 14, 21 days for an office space occupied Monday through Friday and unoccupied on weekends. The hours/year in the active period may vary by

usage group; in schools, for example, office spaces may be active 8,760 hours/year, while classrooms are only active 6,570 hours/year.

5. Evaluation timing requires the protocol meter operating hours after the efficiency project has been completed. The assumption in this process is that the operating hours have remained unchanged from the baseline period. Thus, HOU baseline and HOU energy-efficient in Equation 1 have the same value. (Note that will not be the case if the project includes lighting control measures.)
6. Chapter 3: *Lighting Controls Evaluation Protocol* addresses lighting control measures, but Equation 1 can accommodate changes in lighting operating hours, as would occur in combined lighting equipment and lighting controls projects, provided measured hours of use data are available for the baseline period. For example, these data may be available for a facility with an energy management system with archived trends or if a lighting contractor conducted a metering study before entering into a performance contract.

6.4 Report M&V and Program Savings

Information collected during the M&V processes is used to calculate M&V project savings, as follows:

1. Using the results from the last step in the measurement process and the sample lighting inventory form from the verification process, update the inventory HOU parameters and calculate M&V savings for the sample of projects.
2. Calculate the program realization rate, the M&V project savings divided by the reported project savings for the sample.

Equation 8. Program Realization Rate

$$Realization\ Rate_{kWh,kW} = \frac{\sum kWh, kW_{M\&V}}{\sum kWh, kW_{Reported}}$$

3. Calculate the evaluated program savings, the product of the program realization rate and the program reported savings.

Equation 9. Evaluated Program Savings

$$Evaluated\ Savings_{kWh,kW} = Realization\ Rate_{kWh,kW} \cdot kWh, kW_{Reported}$$

The uncertainty and, therefore, the reliability of the program realization rate depend on the sample size and variance in the findings (described later in Chapter 11: *Sample Design*). These are usually a function of the confidence and precision targets stipulated by regulators or administrators, and evaluation budgets. The sample sizes for homogeneous lighting efficiency programs can range from as few as 12 for an 80/20 confidence/precision target to as many as 68 (or more) for a 90/10 target.

6.5 Data Requirements and Sources

This section contains information on the fixture wattage, annual HOU, interactive cooling, and interactive heating factor parameters found in the algorithm equations. Data requirements are described in *Role of the Lighting Program Implementer* and *Role of the Evaluator*, with additional detail in *Measurement and Verification Plan*.

6.5.1 Fixture Wattage

The protocol recommends use of fixture wattage tables, developed and maintained by existing energy efficiency programs and associated regulatory agencies. The tables list all common fixture types, and most are updated as new fixtures and lighting technologies become available.

The wattage values are measured according to ANSI standards[3] by research facilities working on behalf of manufacturers and academic laboratories.

In the wattage table, each fixture and screw-in bulb is fully described and assigned a unique identifier. The implementer enters a fixture code into a lighting inventory form, which, if programmed, can search by a lookup function to show the associated demand. The evaluator then verifies or corrects the fixture type for the evaluation sample, and updates the lighting wattage values.

The protocol recommends adopting a fixture wattage table, used by an established and recognized lighting efficiency program. As of May 2012, the following sources provide examples (many others are available in most U.S. regions):

- *Massachusetts Technical Reference Manual 2011*, Massachusetts Device Codes and Rated Lighting System Wattage Table. Available from the Massachusetts Energy Efficiency Advisory Council, www.ma-eeac.org/index.htm. This is a slightly abbreviated and simplified table of common fixtures and their wattages.
- *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs 2010*, Appendix C Standard Fixture Watts. Available from the New York Department of Public Service: www.dps.ny.gov/TechManualNYRevised10-15-10.pdf. This is a comprehensive (34 pages) list, used by NYSERDA since the late 1990s, with recent data from California impact evaluation studies.
- Database for Energy Efficiency Resources (DEER). Available from the California Public Utilities Commission at: www.deeresources.com. An exhaustive list of all parameters driving energy use and savings for a lengthy list of measures. References California codes and weather zones.

Wattage tables are used by both the implementer and the evaluator. An excerpt from the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* is included in the *Appendix* to this protocol as an example of a wattage table.

6.5.2 Hours of Use

The protocol requires the evaluator to measure operating hours for a sample of buildings and fixtures, as described in *Measurement Process*.

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3 The ANSI 82.2-2002 test protocol specifies ambient conditions for ballast/lamp combinations in luminaires. The test is conducted on an open, suspended fixture. Actual fixture wattage will vary, depending on the installation (suspended, recessed) and housing type. Differences are small—less than 5% (see DOE 1993 Advanced Lighting Guidelines).

This section describes data sources and methods used by the program implementer for estimating HOU values for individual projects. Accurate estimates of the HOU parameter are needed for the implementer to report project and program savings reliably. Accurate reporting by the implementer also results in more accurate evaluated savings for a given sample size.

The protocol requires program participants to provide estimates of HOU values by usage group in their lighting inventory forms. The estimate should not be based on the building schedule alone, although this may inform the estimate. Instead, the protocol recommends participants develop the HOU values using one of the following sources, with guidance from the program implementer:

- ***Lighting schedules in buildings with energy management systems or time clocks*** controlling lighting equipment. The project participant should interview the building manager to verify the schedules are not overridden. Control schedules (or trend data) are reliable estimates of true lighting operating hours, but they are normally available only for larger, newer facilities.
- ***Interviews with building managers.*** Building managers are usually familiar with lighting schedules, and can describe when lights are turned on and off for typical weekdays and weekends. They may not know about abnormalities such as newly vacant spaces, how cleaning crews operate lights, or whether lights are actually turned off after hours. The protocol recommends interviewing two or more people familiar with a facility's operation to verify scheduling assumptions.
- ***Tables of HOU values by building type*** provided by the program implementer. HOU values have been developed from impact evaluation and M&V studies for many commercial and nonresidential buildings. Like wattage tables, HOU tables are maintained by energy efficiency programs and associated regulatory agencies; sources can be found using the same references provided for wattage tables. An excerpt from the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* is included in the *Appendix* to this protocol as an example of a table of HOU values.

Actual operating schedules vary widely for any given building type, and tabulated average values provide more approximate estimates with larger variations than values for fixture wattages. Also, tabulated HOU values are given for entire buildings, not by usage groups within buildings. The protocol requires HOU estimates be entered into the inventory by usage group, which will vary from the building average. For these reasons, the protocol recommends use of building-specific lighting operating hours when these are available, supplemented if necessary by tables of HOU values.

6.5.3 Interactive and Coincidence Factors

Energy-efficient lighting equipment produces less waste heat in building conditioned spaces, compared to baseline equipment. This results in a reduced cooling load and an increased heating load. Interactive factors—terms IF_c and IF_h in *Algorithms*—account for these additional changes in energy use.

Interactive cooling effects are generally small for spaces conditioned for human comfort (2% to 6% for cooling in offices in New York City, for example.[4]) They are also highly dependent on HVAC system types and efficiencies. For example, in a large office building in New York City, the IF_c varies with the equipment: (1) with gas heat and no economizer, the IF_c is 3.3%, (2) with an economizer, the IF_c is 1.9%, and (3) with economizer and a variable air volume system, the IF_c is 6.5%. In regions with mild or hot climates where cooling loads are higher than in New York City, IF_c values will be larger than these examples.

Interactive heating effects may be up to 100%, meaning that the reduced waste heat caused by improved lighting efficiency must be supplied by a boiler or other heating system during the heating season. Electric efficiency programs often ignore interactive heating effects when territory's heating systems are primarily nonelectric; e.g., natural gas or oil. For comprehensive programs with an all-fuels reporting responsibility, the increased heating energy can be included.

Interactive factors are usually too small to be measured accurately; instead, they are developed using computer simulations and the interactive impacts are stipulated. Interactive effects are available from the same sources as fixture wattages and HOU.

Interactive effects can be significant in cold-temperature conditioned spaces, such as freezers or refrigerated warehouses. For example, in Pennsylvania, the default interactive cooling factors are defined by space temperature ranges as follows:[5]

- Freezer spaces (-20 °F–27 °F) = 50%
- Medium-temperature refrigerated spaces (28 °F–40 °F) = 29%
- High-temperature refrigerated spaces (47 °F–60 °F) = 18%
- Uncooled space (e.g. warehouse with no mechanical cooling) = 0%.

Not all programs estimate, report, and evaluate interactive effects, and the decision is often a policy choice. Further, because programs are often energy specific (electricity or gas), the effect on other fuels is sometimes ignored. For example, electric energy efficiency programs might report interactive electric cooling savings, but omit interactive increases in gas heating energy.

CFs adjust the change in connected electric load from lighting efficiency projects for electric peak demand savings. Electric demand savings that occur during utility system peak periods help to lower utility capacity requirements, reducing the load on peak generation equipment that is usually the most costly to operate and improving system reliability. The value of peak demand generation is reflected in rate structures that charge customers for their demand during peak time-of-use periods.

CFs can range from a high of 1.0 down to 0.0, where 1.0 indicates that 100% of a lighting project's change in connected load occurs during the utility peak period. An example is the CF of

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4 TecMarket Works. October 2010. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs," Appendix D.

5 Pennsylvania Public Utility Commission. 2011. "Technical Reference Manual." P. 138.

1.0 for commercial lighting efficiency projects in New York State.[6] Typically, dawn-to-dusk exterior lighting has a CF of 0.0.

CFs can be developed from lighting HOU meter data. The CF is the peak period energized lighting kW as measured by the meter data, divided by the total kW for the energy efficiency lighting project.

When accurate estimates of interactive values are available, the protocol recommends program implementers and evaluators use tables of IFs to report interactive effects for cooling and heating energy. The recommended sources for values of IFs, ranked by reliability, are:

- Computer simulations of typical buildings found in the program's territory and weather zones
- Interactive factors developed for similar programs and climates
- An average single value, developed from one or more tables of interactive factors for similar programs and climates.

Because the interactive effect is usually small relative to the primary energy savings from a lighting efficiency project, program planners often borrow IFs developed for similar programs and climates.

The protocol also recommends using tables of CFs (including any interactive effects from reduced cooling loads) to report system peak coincident electric demand savings. If regulators or program administrators require greater reliability for evaluated demand reductions (as would occur for a program designed to increase capacity reserves), CFs should be developed from metered data. Like IFs, unique CFs can also be adapted from programs with similar customer and utility profiles.

A sample of IFs and CFs can be found in the documents listed in *Resources*.

[6] TecMarket Works. P. 110.

7 Impact Evaluation

Evaluations entail a detailed review of a sample of completed projects, concluding with an independent assessment of their savings. The ratio of program-claimed savings and evaluated savings for the projects (the realization rate) is used to adjust claimed savings for all completed projects (the program).

Evaluations are coordinated in conjunction with program milestones, usually at the end of a program year or cycle. The evaluation's subject is the population of all projects completed up to the milestone.

It is preferable to begin evaluation activity before the program cycle ends, because difficulties and inaccuracies often occur when collecting data retroactively, particularly in attempts to backfill missing data, determine baseline data, or deal with poor customer recall of project details. This may require drawing a preliminary sample before the milestone date and then adjusting (adding to) the sample after the milestone date.

The evaluator uses the same algorithms and data as the program implementer (subject to review and site inspections), except that HOU values are based on measurements of actual lighting operating hours for all projects in the evaluation sample, and lighting inventories (including fixture types and counts) are corrected as needed based on on-site reviews of the sample projects.

The ratio of evaluator savings to program reported savings for the projects in the M&V sample is the program realization rate. Total reported program savings for the reporting period are then multiplied by the program realization rate to determine program evaluated savings for the period.

7.1 Sample Design

The protocol requires sampling to select:

- Projects from a program database for an impact study
- Inventory lines for deploying light loggers.

Regulators normally prescribe the confidence and precision levels for the sample, or the implementer may impose them. (Chapter 11: *Sample Design* describes general sampling procedures and should be consulted when developing evaluation plans for lighting efficiency programs.) The following details pertain specifically to lighting.

The protocol recommends stratified sampling when selecting projects for an impact study because it usually results in smaller sample sizes as compared to simple random sampling. The idea behind stratified sampling is to select subpopulations of relatively homogeneous projects such that the variance within each stratum is smaller than for the population as a whole, as explained in Chapter 11: *Sample Design*.

A simplified stratified strategy is to rank all projects in the population to be studied by their reported savings (ranked from largest to smallest) and to define three strata. The top stratum contains large projects that cumulatively account for 50% of reported savings, and the remaining projects are grouped into medium strata contributing 30% and small strata contributing 20%.

A more rigorous method is to use a stratified ratio estimation approach in which techniques are employed to define strata that minimize the expected variance in their realization rates, and thereby minimize the sample size. Stratified ratio estimation is fully explained in Chapter 11: *Sample Design*, which should be referenced when developing sampling plans.

Light-logger studies also use stratified sampling for projects selected for M&V by selecting samples of fixtures for metering, with strata defined by usage groups. The desired confidence and precision interval (typically prescribed with an assumed coefficient of variation of 0.5) determines the sample size. The Federal Energy Management Program (FEMP) M&V Guidelines[7] describe a detailed routine for selecting logging lines.

Oversampling by 10% to 30% is recommended, either to replace participants that cannot be scheduled for a site visit, or to provide a cushion against lost or failed loggers in HOU studies.

7 www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf

8 Other Evaluation Issues

8.1 Upstream Delivery

As upstream buy-down programs cannot access their individual customers, they lack the lighting inventory forms (with associated data) used to estimate savings. Implementers can use survey methods to estimate baseline fixture wattages and HOUs. Surveys require intercepting customers at the time of purchase to register their names and phone numbers.

Implementers can also draw on incentive and rebate program data by analyzing baseline fixtures and operating hours associated with fixtures promoted in the upstream buy-down program, thereby developing savings factors for upstream buy-down equipment.

8.2 New Construction

Installed power (kW) savings for new construction projects are calculated by subtracting as-built building lighting power from the lighting power of a code-compliant alternative. Lighting power equals lighting power density (watts/ft^2) times building area. HOUs are determined using the same methods as in incentive and rebate programs.

8.3 First Year Versus Lifetime Savings

This protocol provides planners and implementers with a framework for reliable accounting of energy and demand savings resulting from lighting efficiency programs during the first year of measure installation.

Savings over the life of a measure usually will be less (sometimes dramatically so) than the product of first-year savings and measure life. The discount results from performance degradation and equipment failure or replacement. Lifetime savings are covered further in Chapter 13: Assessing Persistence and Other Evaluation Issues. However, because lifetime savings for lighting projects are strongly driven by federal standards and changes in the market, they are discussed here.

Beginning in July 2012, most T12 lamps will not meet federal efficacy (lumens/watt) standards, accelerating a long-term trend toward T8 and T5 lamps and electronic ballasts. The effect is that first-year savings for T12 to T8 replacements can be assumed only for the remaining useful life of T12 equipment, at which point customers have no choice but to install equipment meeting the new standard.

For retrofit lighting programs, at the time when old equipment would be replaced, there is effectively a step up in the baseline and a step down in the annual savings for the replacement equipment. This leads to a dual baseline:

- An initial baseline with full first-year savings
- An efficient baseline with reduced savings for the remaining effective useful life.

The federal standard prohibits the manufacture of T12 lamps with current efficacy ratings. However, it is anticipated that sufficient stock will be available in the market for several years for burnout replacement. Regulators and administrators will need to consider T12 availability before instituting a dual baseline as a result of the standard.

The protocol methodologies, which specify tracking data for each installation, support the calculation of lifetime savings (including the use of a dual baseline).

8.4 Program Evaluation Elements

Building a foundation for a successful evaluation of a commercial, industrial, non-residential lighting program begins early in the program design phase. Implementers support future evaluations by ensuring data required to conduct an impact study are collected, stored, and checked for quality. These data include measured and estimated values available from past studies or equipment tests. Implementers must set data requirements before a program’s launch to ensure that the information required to conduct the research will be available.

9 Resources

Note: This protocol depends heavily on reliable estimates of fixture wattages and HOU, CF, and IF values. A rich body of publicly available research provides these data, which can be found in the resources listed below. Although this is not an exhaustive list, it is representative. Users should select the references that best match their markets and program needs.

The documents cited below have been produced through regulatory and administrative processes, and, as they were developed with considerable oversight and review, they are considered reliable by each sponsoring jurisdiction for their intended applications. HOU, CF, and IF values have been developed from primary data collected during project M&V reviews or evaluation studies, or they are based on engineering analysis. Some of these references provide source documentation.

Fixture wattages are generally based on manufacturers' ratings, obtained during tests conducted according to ANSI standards, although this is not well documented in these sources. Fixture wattages are independent of geographic location. Also, HOU values also tend to be consistent for non-residential building types regardless of location. The sources cited here can be used for these parameters in any service territory.

IF and CF parameters, on the other hand, are dependent on local conditions (weather and system load shape) and users should select carefully so that the referenced values reflect local conditions. Alternatively, local IF and CF parameters can be developed using computer simulations and system load shapes for the service territory where they will be used.

California Energy Commission. (CEC) (1993). *Advanced Lighting Guidelines*.

"Database for Energy Efficient Resources (DEER)." California Public Utilities Commission (CPUC). (2008). www.deeresources.com.

Federal Energy Management Program (FEMP). (2008). *M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 3.0*. www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf.

Massachusetts Program Administrators. (October 2011). *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures 2012 Program Year–Plan Version*. www.masssave.com.

TecMarket Works. (October 2010). *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs—Residential, Multi-Family and Commercial/Industrial Measures*. Prepared for the New York Public Service Commission. http://www3.dps.ny.gov/W/PSCWeb.nsf/All/06F2FEE55575BD8A852576E4006F9AF7?OpenDocument.

Vermont Energy Investment Corporation. (2010). *State of Ohio Energy Efficiency Technical Reference Manual*. Prepared for the Public Utilities Commission of Ohio. http://amppartners.org/pdf/TRM_Appendix_E_2011.pdf.

Pennsylvania Public Utility Commission. (2011). *Technical Reference Manual*, Appendix C. www.puc.state.pa.us/electric/Act129/TRM.aspx.

10 Appendix

Table 3: Example Lighting Inventory Form

Project Name:	Example Building Lighting Project #3
Site Name:	Example Building
Utility Acct Number(s):	XXX-XXXXXXXXXX
Type of Heating Equipment:	Gas fired boiler
Type of Cooling Equipment:	Rooftop DX
Facility Type:	Office
Facility Location:	NYC
Facility Square Feet	40,000
Date(s) Survey completed:	
Survey completed by (name):	

INSTRUCTIONS

				PRE-INSTALLATION					POST-INSTALLATION										
Area Description	**Usage Group ID**	**Heat?**	**Cool?**	**Pre Fixt. No.**	**Pre Fixt. Code**	**Pre Watts/Fixt**	**Pre kW/Space**	**Existing Control**	**Post Fixt No.**	**Post Fixt Code**	**Post Watts/ Fixt**	**Post kW/Space**	**Proposed Control**	**kW Saved**	**Heating InterActive Factor**	**Cooling InterActive Factor**	**Baseline Annual Hours**	**Proposed Annual Hours**	**Annual kWh Saved**
Unique description of the location that matches the site map	Descriptive name for the usage group	Yes or No	Yes or No	Number of fixtures before the retrofit	Code from Table of Standard Fixture Wattages	Value from Table of Standard Fixture Wattages	(Pre Watts/Fixt) * (Pre Fixt No.)	Pre-installation control device	Number of fixtures after the retrofit	Code from Table of Standard Fixture Wattages	Value from Table of Standard Fixture Wattages	(Post Watts/Fixt) * (Post Fixt No.)	Post-installation control device	(Pre kW/Space) - (Post kW/Space)	Change in heating energy due to lighting project	Change in cooling energy due to lighting project	Existing annual hours for the usage group	Propsed annual hours for the usage group	[(Pre kW/Space * Baseline Annual Hours) - (Post kW/Space * Proposed Annual Hours)] * (1+Heat-IF)
Room 343	Office	Yes	Yes	8	2F40SEM	70	0.56	Switch	8	2F25EEE	43	0.34	Switch	0.22	-	0.03	2,500	2,500	558
Room 344	Office	Yes	Yes	3	2F40SEM	70	0.21	Switch	3	2F25EEE	43	0.13		0.08	-	0.03	2,500	2,500	209
Corridor Floor 3	Hallway	Yes	Yes	17	1F40SEE	38	0.65	Switch	17	1F25EEE	30	0.51		0.14	-	0.03	3,700	3,700	520
Women RR Flr 3	Restroom	Yes	Yes	4	110060	60	0.24	Switch	4	1C00185	20	0.08		0.16	-	0.03	3,700	3,700	612
Men RR Flr 3	Restroom	Yes	Yes	4	110060	60	0.24	Switch	4	1C00185	20	0.08		0.16	-	0.03	3,700	3,700	612
	TOTAL			**36.00**		**298.00**	**1.90**		**36.00**	**1.14**	**156.00**	**1.14**		**0.75**					**2,510**

Table 4: New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs New York Department of Public Service Appendix C: Standard Fixture Watts (excerpt, page 270)

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F42SSILL	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	28	48
F41SSILL/T4	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	28	47
F42SSILL-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	28	45
F41SSILL/T4-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	28	44
F42SSILL-H	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-2.2)	Electronic	2	28	67
F42ILL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	56
F42ILL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	51
F42ILL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	65
F42ILL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	32	52
F42ILL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	2	32	79
F42LE	F32T8	Fluorescent, (2) 48", T-8 lamp	Mag-ES	2	32	71
F42LL	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	60
F42LL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	59
F42LL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	53
F42LL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	70
F42LL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	32	54
F42LL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	32	85
F42SE	F40T12	Fluorescent, (2) 48", STD lamp	Mag-ES	2	40	86
F42GHL	F48T5/HO	Fluorescent, (2) 48", STD HO T5 lamp	Electronic	2	54	117
F42SHS	F48T12/HO	Fluorescent, (2) 48", STD HO lamp	Mag-STD	2	60	145
F42SIL	F48T12	Fluorescent, (2) 48", STD IS lamp, Electronic ballast	Electronic	2	39	74
F42SIS	F48T12	Fluorescent, (2) 48", STD IS lamp	Mag-STD	2	39	103

(Reference: NYSERDA Existing Buildings Lighting Table with Circline Additions from CA SPC Table)

Table 5: New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs 2010. Page 109.

Facility Type	Lighting Hours	Facility Type	Lighting Hours
Auto Related	4,056	Manufacturing Facility	2,857
Bakery	2,854	Medical Offices	3,748
Banks	3,748	Motion Picture Theatre	1,954
Church	1,955	Multi-Family (Common Areas)	7,665
College – Cafeteria(1)	2,713	Museum	3,748
College - Classes/Administrative	2,586	Nursing Homes	5,840
College - Dormitory	3,066	Office (General Office Types) (1)	3,100
Commercial Condos(2)	3,100	Office/Retail	3,748
Convenience Stores	6,376	Parking Garages	4,368
Convention Center	1,954	Parking Lots	4,100
Court House	3,748	Penitentiary	5,477
Dining: Bar Lounge/Leisure	4,182	Performing Arts Theatre	2,586
Dining: Cafeteria / Fast Food	6,456	Police / Fire Stations (24 Hr)	7,665
Dining: Family	4,182	Post Office	3,748
Entertainment	1,952	Pump Stations	1,949
Exercise Center	5,836	Refrigerated Warehouse	2,602
Fast Food Restaurants	6,376	Religious Building	1,955
Fire Station (Unmanned)	1,953	Restaurants	4,182
Food Stores	4,055	Retail	4,057
Gymnasium	2,586	School / University	2,187
Hospitals	7,674	Schools (Jr./Sr. High)	2,187
Hospitals / Health Care	7,666	Schools (Preschool/Elementary)	2,187
Industrial - 1 Shift	2,857	Schools (Technical/Vocational)	2,187
Industrial - 2 Shift	4,730	Small Services	3,750
Industrial - 3 Shift	6,631	Sports Arena	1,954
Laundromats	4,056	Town Hall	3,748
Library	3,748	Transportation	6,456
Light Manufacturers(1)	2,613	Warehouse (Not Refrigerated)	2,602
Lodging (Hotels/Motels)	3,064	Waste Water Treatment Plant	6,631
Mall Concourse	4,833	Workshop	3,750